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MANUAL OF ANATOMY

SYSTEMATIC AND PRACTICAL, INCLUDING EMBRYOLOGY

MANUAL OF ANATOMY

SYSTEMATIC AND PRACTICAL, INCLUDING EMBRYOLOGY

BY

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A MANUAL OF ANATOMY

THE ABDOMEN

MALE PERINEUM.

Landmarks.—The tuber ischii can be felt on either side, as well as the ischio-pubic ramus; but the great sacro-sciatic ligament cannot be felt, on account of the thickness of the lower border of the gluteus maximus. The tip of the coccyx is very accessible to the finger.

The perineum practically corresponds with the outlet of the pelvis, and is somewhat lozenge-shaped, having the subpubic angle in front, the tip of the coccyx behind, and the tuber ischii on either side. It is conveniently divided into two parts by a line connecting the ischial tuberosities, each division being triangular. The anterior represents the uro-genital or urethral division, this being the perineum proper, and the posterior the ischio-rectal or anal division. The skin of the uro-genital division presents an antero-posterior median elevation, called the perineal raphé, which extends over the posterior and anterior surfaces of the scrotum, and along the under surface of the penis. The position of the deeply-placed central tendinous point of the perineum is indicated by taking a point in this raphé very nearly 1 inch in front of the anus.

The **anus** is the external opening of the anal canal. It is situated posterior to a line connecting the front parts of the ischial tuberosities, and about 1½ inches from the tip of the coccyx. A delicate white line surrounds the anus where the skin and mucous membrane meet, which indicates the separation between the external and internal sphincter muscles (Hilton). The position of each ischio-rectal fossa is indicated by a slight depression between the anus and tuber ischii.

Deep Boundaries of the Perineum—*Anterior.*—The subpubic angle and subpubic ligament. *Posterior.*—The coccyx. *Lateral.*—From behind forwards, the inferior border of the great sacro-sciatic ligament, tuber ischii, and ischio-pubic ramus.

Ischio-Rectal Division.

Cutaneous Nerves.—These are (1) the **hemorrhoidal** or **perineal branch** of the lower part of the anterior primary division of the

fourth sacral, and (2) the **inferior hemorrhoidal nerve**, which is a branch of the pudic. The former supplies the integument between the tip of the coccyx and the back of the anus, and the latter the integument between the anus and tuber ischii.

Fascia.—The fascia of this division is very thick, and is prolonged into the ischio-rectal fossa, where it forms an elastic pad for the lower part of the rectum and the anal canal. There is no deep fascia.

Ano-coccygeal Body.—This is a collection of fibrous and muscular tissues situated between the coccyx and anal canal, the muscular element being connected with the levatores ani and sphincter ani muscles (Symington). Its importance lies in the fact that it gives support to the anal canal.

Muscles.—The muscles in this division are the sphincter ani externus, corrugator cutis ani, levator ani, and coccygeus.

Sphincter Ani Externus—*Origin.*—The tip of the coccyx and the integument over it.

Insertion.—The greater part of the muscle is inserted into the central tendinous point of the perineum. The more superficial fibres, however, are inserted into the skin, and a certain amount of decussation takes place across the middle line.

Nerve-supply.—The part of the muscle between the coccyx and the anus is supplied by the hemorrhoidal or perineal branch of the fourth sacral, and the remainder by the inferior hemorrhoidal and the deep branch of the perineal nerve, both of which are derived from the pudic.

Action.—To keep the anal aperture closed, at the same time producing a wrinkled condition of the skin.

The muscle is situated immediately beneath the skin, and is elliptical. Behind and in front of the anus it is single, but around that aperture it is arranged in two symmetrical halves, which are intimately connected with the middle portions of the levatores ani.

Corrugator Cutis Ani (Ellis).—This muscle is represented by a very delicate sheet of involuntary muscular fibres, which pass in a radiating manner from the submucous tissue of the anal aperture to be inserted into the surrounding skin.

Action.—(1) To throw the integument around the anus into wrinkles; and (2) to invert the mucous membrane of the lower end of the anal canal after it has been everted during defæcation.

For the **levator ani** and **coccygeus**, see pp. 807 and 808.

Ischio-rectal Fossa.—This is a deep fossa which is situated on either side between the ischium and rectum. It measures nearly 2½ inches in depth, 2 inches from before backwards, and 1 inch from side to side. In transverse section it is triangular, the base being directed downwards and the apex upwards. The **outer wall,** which is vertical, is formed by the lower part of the obturator internus muscle covered by the obturator fascia. The **inner wall,** which is oblique and longer than the outer, is formed by the lower part of the rectum, the anal canal, the levator ani muscle covered by the anal fascia, and the sphincter ani externus. The **base** is

formed by the skin and fascia which extend between the tuber ischii and anus. The **apex** is just below the *white line*, where the anal fascia springs from the obturator fascia. *Anteriorly* the fossa is partially limited by the reflection of the fascia of Colles round the posterior border of the superficial transverse perineal muscle to join the base of the triangular ligament of the urethra. Above this junction there is a forward prolongation of the fossa, called the *anterior diverticulum*, which extends almost to the symphysis pubis. It lies between the postero-superior layer of the triangular ligament and the inferior surface of the anterior part of the levator ani muscle,

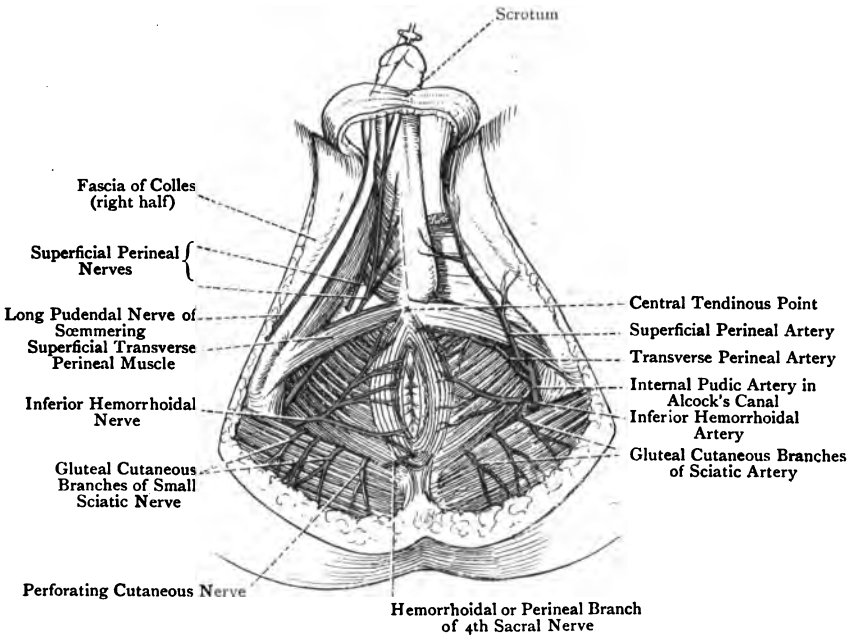
Scrotum
Fascia of Colles (right half)
Superficial Perineal Nerves
Long Pudendal Nerve of Sœmmering
Superficial Transverse Perineal Muscle
Inferior Hemorrhoidal Nerve
Gluteal Cutaneous Branches of Small Sciatic Nerve
Perforating Cutaneous Nerve
Central Tendinous Point
Superficial Perineal Artery
Transverse Perineal Artery
Internal Pudic Artery in Alcock's Canal
Inferior Hemorrhoidal Artery
Gluteal Cutaneous Branches of Sciatic Artery
Hemorrhoidal or Perineal Branch of 4th Sacral Nerve

FIG. 267—DISSECTION OF THE MALE PERINEUM

(On the left side the bulbo-cavernosus has been removed, and the crus penis cut).

and its lateral limits are the prostate gland and pubo-prostatic ligament internally, and the ischio-pubic ramus externally. *Posteriorly* the fossa is partially limited by the margin of the great sacro-sciatic ligament and the lower border of the gluteus maximus muscle. Between these two structures it is prolonged backwards for a short distance in the form of a *posterior diverticulum*, which extends outwards towards the tuber ischii, and inwards towards the upper part of the coccyx.

Position of Contents.—The internal pudic vessels and the perineal and dorsalis penis branches of the pudic nerve lie upon the outer

wall about 1½ inches above the lower part of the tuber ischii, and they are contained in Alcock's canal. The inferior hemorrhoidal vessels and nerve cross the fossa transversely from the outer wall to the anal canal. The superficial perineal vessels and nerves on their way forwards lie for a short distance in the front part. At the back part of the fossa, winding round the lower border of the gluteus maximus, the gluteal cutaneous branches of the small sciatic nerve and sciatic artery, as well as the perforating cutaneous branch of the sacral plexus, are met with.

The fossa is filled with loose fat, which also extends into the anterior and posterior diverticula.

This fat is badly supplied with bloodvessels, and its vitality is therefore low. As a consequence, an ischio-rectal abscess is of not infrequent occurrence. When an abscess forms, the pus has a tendency to discharge itself in two directions, namely, through the skin forming the floor of the fossa, and through the wall of the anal canal about half an inch above the anus. When this happens a complete *fistula in ano* is the result.

The severe pain which accompanies an ischio-rectal abscess is due to pressure upon the following nerves: (1) the inferior hemorrhoidal; (2) the two superficial perineal nerves; and (3) the gluteal cutaneous branches of the small sciatic.

Uro-Genital Division.

Superficial Fascia.—The superficial fascia resembles that over the lower part of the anterior wall of the abdomen in being divisible into two layers, which are called the subcutaneous layer and the deep layer or fascia of Colles.

The **subcutaneous layer** is fatty and granular. When followed backwards on either side it forms the floor of the ischio-rectal fossa. At the middle line it is continuous with the corresponding layer of the opposite side. Externally it passes freely over the ischio-pubic ramus, and is continuous with the superficial fascia of the inner side of the thigh. Anteriorly it passes into the scrotum, where it joins the deep layer or fascia of Colles. The resultant fascia, now free from adipose tissue, contains involuntary muscular tissue, and forms the tunica dartos. The subcutaneous layer represents the fascia of Camper of the lower part of the anterior abdominal wall.

The **deep layer** constitutes the **fascia of Colles.** It is membranous and strong. *Externally*, it is attached to the anterior everted lip of the inner border of the ischio-pubic ramus, as far back as the tuber ischii, immediately outside the attachment of the crus penis. *Internally*, the fascia of one side is continuous with that of the other along the middle line. *Posteriorly*, the fascia turns round the posterior border of each superficial transverse perineal muscle, and joins the base of the triangular ligament. *Anteriorly*, it passes into the scrotum, where it joins the subcutaneous layer, the two forming the tunica dartos.

The fascia of Colles represents the fascia of Scarpa of the anterior abdominal wall. It encloses a space over the anterior division of the perineum, called the **perineal pouch.** This pouch is partially

subdivided into two compartments by an incomplete septum, which extends upwards from the deep or superior surface of the fascia of Colles to be attached to the median raphé above. This septum is only complete for a short distance at the back part; elsewhere it is very imperfect, and is continued forwards into the scrotum.

When air is blown beneath the back part of the fascia of Colles on one side of the middle line, the fascia of that side and the corresponding half of the scrotum become distended. As more air is blown in, the fascia of the opposite side and the corresponding half of the scrotum also become distended.

It is into the perineal pouch that urine is extravasated in rupture of the urethra in the perineum. In such cases the urine cannot pass into either ischio-rectal fossa, its backward course being arrested at the posterior borders of the superficial transverse perineal muscles, where the fascia of Colles, as a whole, turns round to join the base of the triangular ligament. Neither can the urine make its way down the inner side of the thigh, its passage in this direction being stopped at the ischio-pubic ramus to which the fascia of Colles is attached. The only course, therefore, which is impressed upon the extravasated urine is forwards into the scrotal wall and on to the penis, in each case beneath the dartos tunic, whence it passes upwards along the spermatic cord to the anterior wall of the abdomen, in which situation it lies beneath the fascia of Scarpa.

The fascia of Colles covers the following structures: the crura penis, covered by the ischio-cavernosi muscles; the bulb of the urethra, covered by the bulbo-cavernosi muscles; the superficial transverse perineal muscles; the superficial perineal vessels of each side; the three long scrotal nerves of each side; and the deep perineal triangle of each side, in the area of which is one half of the antero-inferior layer of the triangular ligament.

Muscles—Transversus Perinæi Superficialis—*Origin.*—The inner aspect of the tuber ischii above the origin of the ischio-cavernosus.

Insertion.—The central tendinous point of the perineum.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—To draw back and fix the central tendinous point, and so to aid the action of the bulbo-cavernosus.

The muscle is directed obliquely inwards and forwards, being accompanied by the transverse perineal artery, and it forms the base of the deep perineal triangle.

Ischio-cavernosus (erector penis)—*Origin.*—(1) The inner aspect of the tuber ischii close below the origin of the superficial transverse perineal muscle; and (2) the inner border of the ramus of the ischium on either side of the crus penis.

Insertion.—The under surface of the fibrous sheath of the crus penis in its front part, and the outer and upper surfaces of the fibrous sheath of the corpus cavernosum penis, in which latter situation it is continuous with the fascial investment of the penis and with the insertion of the suspensory ligament of that organ.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—The muscle compresses the crus penis against the ischio-pubic ramus, and, by retarding the return of venous blood, it helps to maintain the penis in a state of erection. It also contributes to the maintenance of erection by compressing the dorsalis penis vein.

The anterior and outer part of the muscle is sometimes detached, and forms a separate muscle, called the **compressor venæ dorsalis penis.** This arises from the descending pubic ramus, anterior to the origin of the ischio-cavernosus, and it terminates in an aponeurotic expansion which joins its fellow of the opposite side over the dorsal vein of the penis.

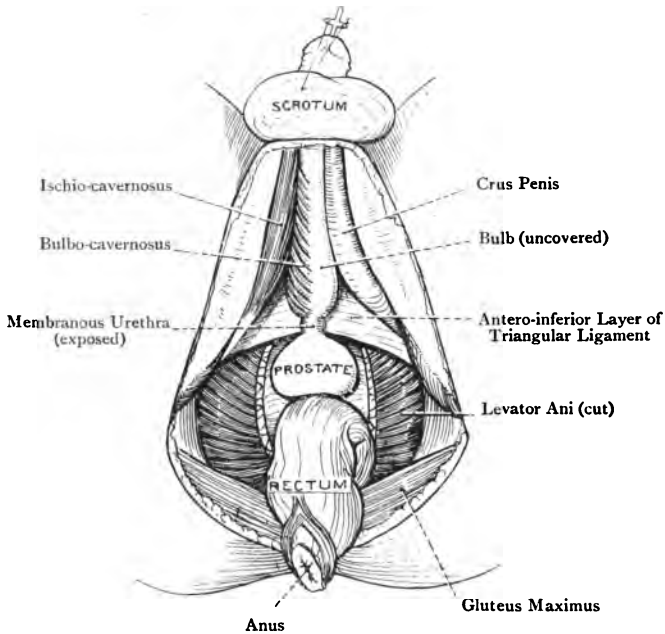

FIG. 268.—DEEP DISSECTION OF THE MALE PERINEUM
(The rectum has been turned back).

Bulbo-cavernosus (accelerator or ejaculator urinæ)—*Origin.*—(1) The central tendinous point of the perineum; and (2) the median raphé, which is continued forwards from that point towards the symphysis pubis.

Insertion.—The muscle, as regards its insertion, is conveniently divided into three parts, namely, the chief part, the anterior part and the posterior part.

Chief Part.—The fibres of this part ascend between the crus penis and the side of the bulb to be inserted into the median raphé on the upper surface of the bulb, where they meet the fibres of the corresponding part of the opposite muscle.

Anterior Part.—The fibres of this part become somewhat detached and form the **muscle of Houston.** They are inserted partly into the outer surface of the fibrous sheath of the corpus cavernosum penis in front of the ischio-cavernosus, and partly by means of a tendinous expansion into the fascial investment of the penis beneath which the dorsal vein of the penis lies.

Posterior Part.—The fibres of this part arch outwards and backwards to be inserted into the antero-inferior layer of the triangular ligament near its base.

Nerve-supply.—The deep division of the perineal branch of the pudic nerve.

Action.—(1) The chief part of the muscle, acting with its fellow, compresses the bulb. These portions of the two muscles, therefore, come into play at the end of the act of micturition, when they expel the last drops of urine from this part of the urethra. A further action is to contribute to the maintenance of erection of the penis by compressing the veins of the bulb. (2) The anterior part compresses the dorsal vein of the penis, and so contributes to the maintenance of erection. (3) The posterior part tends to fix the bulb and maintain it in position.

The chief portions of the bulbo-cavernosi muscles completely surround the bulb, and may be regarded as forming a sphincter muscle to it.

Compressor or **Constrictor Urethræ.**—This muscle is also called the **muscle of Guthrie.** It extends transversely from the inner border of the ischio-pubic ramus of one side to the inner border of the opposite ischio-pubic ramus, lying in each case behind the attachment of the antero-inferior layer of the triangular ligament of the urethra. At the middle line the muscle divides into two layers, which, passing above and below the membranous part of the urethra, form a sphincter muscle to it, the lower layer also ensheathing the glands of Cowper. The posterior fibres of the muscle, which lie close to the base of the triangular ligament, are known as the **transversus perinæi profundus** (Henle). The highest fibres are connected on either side with the pelvic surface of the descending pubic ramus at its upper part, and they join each other below the membranous portion of the urethra. These highest fibres, which are oblique in direction, constitute the **levatores urethræ muscles**, or **muscles of Wilson.**

Nerve-supply.—The dorsal nerve of the penis.

Action.—(1) To constrict the membranous part of the urethra. The muscle comes into play at the end of micturition, and it assists the bulbo-cavernosus in emptying the urethral canal. (2) To contribute to the maintenance of erection of the penis by compressing the plexus of veins, in the muscle, which receives its tributaries from the corpora cavernosa and bulb. (3) To compress Cowper's glands, and so aid in the expulsion of their secretion.

The compressor urethræ muscle lies between the two layers of the triangular ligament of the urethra. Close to its attachment to

the ischio-pubic ramus it contains within its substance the internal pudic vessels and the dorsal nerve of the penis.

Central Tendinous Point.—Nearly 1 inch in front of the anus there is a short transverse tendinous septum, about ½ inch long. At its centre it presents a thickening, to which the name of *central tendinous point* is given. The muscles which meet at this point are as follows: (1) the sphincter ani externus, coming from behind; (2) the bulbo-cavernosi, coming from before; (3) the superficial transverse perineal muscles, coming from either side; and (4) the anterior portions of the levatores ani, which here lie above the posterior portions of the bulbo-cavernosi. The pointed process at the centre of the base of the antero-inferior layer of the triangular ligament of the urethra is also attached to the central tendinous point.

Bulb of the Urethra.—This is the first part of the corpus spongiosum penis, and is so named from its presenting a bulbous enlargement. It measures about 1½ inches in length, and about ¾ inch in breadth at its posterior part. Its posterior extremity rests upon the antero-inferior layer of the triangular ligament, and extends as far back as the central tendinous point, where it lies nearly 1 inch in front of the anus. This part extends fully ¼ inch farther back than the bulbous part of the urethra. It here presents on its under surface, in the middle line, a faint groove indicative of a tendency to a bipartite division at this point. The bulb is invested by a fibrous sheath derived from the circumference of the urethral opening in the antero-inferior layer of the triangular ligament, superficial to which lie the fibres of the chief parts of the bulbo-cavernosi muscles. Each lateral wall of the bulb is pierced by Cowper's duct, which, with its fellow of the opposite side, opens upon the floor of the bulbous part of the urethra fully 1 inch in front of the antero-inferior layer of the triangular ligament.

Crus Penis (crus corporis cavernosi penis).—This is the posterior attached portion of the corpus cavernosum penis. It is attached to the anterior everted lip of the inner border of the ischio-pubic ramus, superficial to the antero-inferior layer of the triangular ligament. Inferiorly and laterally it is covered by the ischio-cavernosus, and it lies beneath the fascia of Colles. The artery of the corpus cavernosum, having pierced the antero-inferior layer of the triangular ligament, passes between the attached surface of the crus and the ischio-pubic ramus, and enters the deep surface of the crus, to be continued forwards in the centre of the corpus cavernosum.

Deep Perineal Triangle—Boundaries—*External.*—The crus penis, covered by the ischio-cavernosus muscle. *Internal.*—The bulb of the urethra, covered by the bulbo-cavernosus muscle. *Posterior*, or *Base.*—The superficial transverse perineal muscle. The *floor* is formed by the fascia of Colles, with the superficial perineal vessels and the three long scrotal nerves. In the undisturbed position of

the parts the area of the triangle is concealed by the approximation of the bulbo-cavernosus and ischio-cavernosus muscles. When, however, these muscles are held apart there is seen lying deeply in the area one half of the antero-inferior layer of the triangular ligament of the urethra.

Subpubic Ligament (ligamentum arcuatum).—This is a thick band which lies at the antero-superior part of the subpubic arch, where it fills up the subpubic angle. It is attached superiorly to the lower part of the interpubic disc, and laterally to the adjacent parts of the inner lips of the descending pubic rami. It is about ¼ inch in depth, and is slightly arched.

Transverse Pelvic or Perineal Ligament.—This band extends transversely between the descending pubic rami two or three lines below the subpubic ligament. Inferiorly it is closely connected with the truncated apex of the antero-inferior layer of the triangular ligament. Between its upper border and the subpubic ligament there is the opening for the backward passage of the dorsalis penis vein.

Triangular Ligament of the Urethra.—This ligament occupies the subpubic arch, which it fills, except at its antero-superior part where it is replaced by the subpubic and transverse pelvic or perineal ligaments. It is composed of two distinct layers, called antero-inferior (perineal) and postero-superior (pelvic). These two layers are united by their bases, but elsewhere they are separated by an interval of about ½ inch, in which the membranous part of the urethra in the male, and the vagina and urethra in the female, along with other structures to be presently enumerated, lie.

The **antero-inferior layer** is also called the **subpubic,** or **deep perineal, fascia.** It is triangular, the apex being truncated. The *apex* is closely connected with the transverse pelvic or perineal ligament, which may be regarded as a part of its fibres. Each *lateral margin* is attached to the inner border of the ischio-pubic ramus, behind its everted lip, on which it extends as far back as the tuber ischii, lying between the attachments of the crus penis and ischio-cavernosus anteriorly and the compressor urethræ posteriorly. In this direction it measures fully 2 inches. The *base* is directed downwards and backwards, and is joined by the base of the postero-superior layer and the fascia of Colles. In the middle line the base is projected into a slight process, which is connected with the central tendinous point of the perineum. On either side of this median process the base presents a concave margin where it sweeps downwards and outwards to the tuber ischii. The length of the antero-inferior layer in the middle line is about 1½ inches. Its fibres are chiefly disposed transversely. The structures which pierce this layer are as follows: the urethra, the arteries of the bulb, the arteries of the corpora cavernosa penis, the dorsal arteries and the dorsal nerves of the penis, the superficial perineal vessels and nerves, and the ducts of Cowper's glands.

Urethral Opening.—This aperture is situated in the middle line

fully 1 inch below the subpubic angle, and it gives exit to the membranous part of the urethra. From the circumference of the opening an expansion is given off, which forms a fascial investment for the bulb.

Openings for the Arteries of the Bulb.—These are two in number, right and left, and are situated one on either side of the upper part of the urethral opening.

Openings for the Arteries of the Corpora Cavernosa Penis.—These are two in number, right and left, and each is situated in the lateral attached border, under cover of the crus penis, about 1 inch below the level of the subpubic angle.

Openings for the Dorsal Arteries and Nerves of the Penis.—These are two in number on either side, and are situated high up,

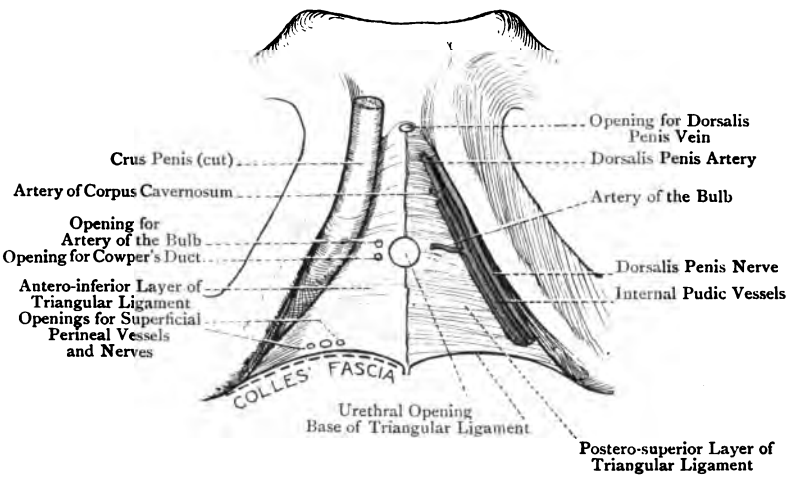
Opening for Dorsalis Penis Vein
Crus Penis (cut)
Dorsalis Penis Artery
Artery of Corpus Cavernosum
Artery of the Bulb
Opening for Artery of the Bulb
Opening for Cowper's Duct
Dorsalis Penis Nerve
Antero-inferior Layer of Triangular Ligament
Internal Pudic Vessels
Openings for Superficial Perineal Vessels and Nerves
COLLES' FASCIA
Urethral Opening
Base of Triangular Ligament
Postero-superior Layer of Triangular Ligament

FIG. 269.—THE TRIANGULAR LIGAMENT OF THE URETHRA
(The antero-inferior layer has been removed on the left side).

being near the subpubic angle, and close to the descending pubic ramus, the opening for the artery being internal to that for the nerve. It is to be noted that the dorsal vein of the penis has a special opening, which is situated in the median line between the subpubic and transverse pelvic or perineal ligaments.

Openings for the Superficial Perineal Vessels and Nerves.—These are situated, on either side, in the base at the line of junction with the fascia of Colles.

Openings for the Ducts of Cowper's Glands.—Each of these is situated on either side of the urethral aperture a little behind and below the opening for the artery of the bulb.

Chief Relations—*Antero-inferior.*—The bulb of the urethra, and the crura penis, covered by their respective muscles, the superficial transverse perineal muscles, and the fascia of Colles. *Postero-*

superior.—The membranous part of the urethra, the glands of Cowper, and the compressor urethræ muscle.

The **postero-superior layer** is weaker and much less defined than the antero-inferior. It lies about ½ inch above and behind that layer, and extends inwards to the urethra from the inner aspect of each ischio-pubic ramus near the posterior lip, where it is behind the compressor urethræ muscle. Superiorly it is attached to the transverse pelvic or perineal ligament, and its base joins that of the antero-inferior layer. At each ischio-pubic ramus it is continuous with the parietal pelvic fascia. When it arrives at the urethra it changes its course, and passes backwards over the anterior border of the levator ani muscle to blend with that portion of the visceral pelvic fascia which ensheathes the prostate gland. The postero-superior layer of the triangular ligament is to be regarded as a part of the parietal pelvic fascia. Antero-inferiorly it is in contact with the membranous part of the urethra and compressor urethræ muscle, whilst postero-superiorly it is related to the anterior fibres of the levator ani of each side, and forms the floor of the anterior diverticulum of the ischio-rectal fossa. The structures which pierce this layer are as follows: the membranous part of the urethra in the male, and the vagina and urethra in the female; and the internal pudic vessels and dorsal nerves of the penis.

Urethral Opening.—This is often a mere cleft, in which cases the postero-superior layer may be described as being arranged in two symmetrical halves. At this opening or cleft it becomes continuous superiorly with the capsule of the prostate gland.

Openings for the Internal Pudic Vessels and Dorsal Nerves of the Penis.—These are situated close to the base, on either side, near the ischial ramus.

Structures between the Layers of the Triangular Ligament.—These are as follows:

1. The membranous portion of the urethra in great part.
2. The glands of Cowper.
3. The compressor urethræ muscle.
4. The internal pudic arteries, each lying close to the ischio-pubic ramus in the compressor urethræ muscle, and each giving off the following branches: (*a*) the artery of the bulb, which in turn gives off the artery of a Cowper's gland; (*b*) the artery of the corpus cavernosum; and (*c*) the dorsal artery of the penis.
5. A plexus of veins which receives its tributaries from the crus (corpus cavernosum) and bulb, and in which the internal pudic venæ comites take their origin.
6. The deep lymphatics of the penis.
7. The dorsal nerves of the penis, each of which lies external to the corresponding internal pudic artery.

Glands of Cowper.—These glands are two in number, right and left. They are situated between the two layers of the triangular ligament, where they lie above the bulb and behind the membranous portion of the urethra, one on either side of the median

line. Each gland is a firm, round, and lobulated mass about the size of a small pea. Both glands are ensheathed by the lower layer of the compressor urethræ muscle, and within this there is the special fibrous capsule which has an admixture of plain muscular tissue. The glands belong to the class of racemose or acino-tubular glands, and each is composed of several lobules. The alveoli or acini are lined with columnar cells. The ducts are two in number, right and left. They are lined with cubical epithelium, and their walls contain plain muscular tissue. Each duct pierces the antero-inferior layer of the triangular ligament on either side of the urethral opening, a little behind and below the artery of the bulb. The duct then pierces the side of the bulb, and opens, with its fellow, upon the floor of the bulbous part of the urethra, fully 1 inch in front of the antero-inferior layer of the triangular ligament. Each gland receives a branch from the artery of the bulb.

Cowper's glands are developed from the epithelial lining of the uro-genital sinus or canal.

Internal Pudic Artery.—This vessel is one of the terminal branches of the anterior division of the internal iliac, the other and larger terminal branch being the sciatic. Lying at first within the pelvis, the artery passes downwards over the pyriformis muscle and sacral nerves, having the sciatic artery usually behind it, and it emerges from the cavity through the lower compartment of the great sacro-sciatic foramen. It then crosses the back of the spine of the ischium, after which it passes through the small sacro-sciatic foramen, and so enters the ischio-rectal division of the perineum. The vessel now courses along the outer wall of the ischio-rectal fossa, where, contained in Alcock's canal, it lies about 1½ inches above the lower part of the tuber ischii. On approaching the anterior part of the fossa the artery gradually becomes more superficial, and, after leaving the fossa, it enters the interspace between the two layers of the triangular ligament of the urethra by piercing the postero-superior layer close to its base and near the ischial ramus. It now passes forwards and upwards, embedded in the compressor urethræ muscle, and lying close to the ischio-pubic ramus, where it is comparatively superficial. Having given off the artery of the bulb about ½ inch above the base of the triangular ligament, the vessel finally divides, about 1 inch below the subpubic angle, into its two terminal branches, the artery of the corpus cavernosum and the dorsal artery of the penis.

In considering the relations and branches of the internal pudic artery it is convenient to divide the vessel into four parts—first, second, third, and fourth.

The **first part** represents the intrapelvic portion of the vessel, and will be found described on p. 788.

The **second part** is the portion of the vessel which lies upon the back of the spine of the ischium. For a description of it see p. 408.

The **third part** is the part of the vessel which lies on the outer wall of the ischio-rectal fossa. It is here contained in Alcock's canal, and is situated about 1½ inches above the lower part of the tuber ischii. For its relations see Alcock's canal.

Branches.—These are as follows: the inferior hemorrhoidal, the superficial perineal, and the transverse perineal.

The **inferior hemorrhoidal artery** arises, either singly or in two or three branches, from the internal pudic immediately after it has taken up its position in Alcock's canal. The branches pass inwards to the anal canal through the loose fat which fills the ischio-rectal fossa. They are distributed to the external sphincter, levator ani, wall of the anal canal, and superficial structures of one half of the ischio-rectal division of the perineum, and they anastomose with the middle and superior hemorrhoidal arteries, and the inferior hemorrhoidal branches of the opposite side.

The **superficial perineal artery** arises from the internal pudic at the anterior part of the ischio-rectal fossa. It pierces the base of the antero-inferior layer of the triangular ligament, and passes superficial to (sometimes on the deep surface of) the superficial transverse perineal muscle. Its subsequent course is forwards under cover of the fascia of Colles, where it lies in the floor of the deep perineal triangle, in company with the three long scrotal nerves. On approaching the scrotum it divides into several long slender branches, which supply the back of the scrotum and anastomose with the external pudic branches of the common femoral artery.

The **transverse perineal artery,** as a rule, arises in common with the superficial perineal, of which it is sometimes regarded as a branch. It may, however, arise directly from the internal pudic immediately in front of the origin of the superficial perineal. It is directed inwards and forwards to the central tendinous point lying superficial to the superficial transverse perineal muscle, and beneath the fascia of Colles. It supplies the muscles which meet at the central tendinous point, and anastomoses with its fellow of the opposite side.

Alcock's Canal.—This canal is situated in the outer wall of the ischio-rectal fossa, and is formed by the obturator fascia. Its contents from below upwards are as follows: (1) the perineal division of the pudic nerve; (2) the lower vena comes; (3) the third part of the internal pudic artery; (4) the upper vena comes; and (5) the dorsal nerve of the penis.

The **fourth part** of the internal pudic artery lies between the two layers of the triangular ligament. It enters this interspace by piercing the postero-superior layer of that ligament close to its base and near the ischial ramus. It is embedded in the compressor urethræ muscle, and is comparatively superficial. As it lies near the ischio-pubic ramus it has a vena comes on either side of it, and the dorsal nerve of the penis is external to it.

Branches.—These are as follows: the artery of the corpus

spongiosum, the artery of the corpus cavernosum, and the dorsal artery of the penis.

The **artery of the corpus spongiosum (artery of the bulb)** arises from the internal pudic about ½ inch above the base of the triangular ligament, and passes transversely inwards in the substance of the compressor urethræ muscle. On approaching the urethra it turns forwards, and, having pierced the compressor urethræ, it passes through an opening in the antero-inferior layer of the triangular ligament at the side of the urethral aperture. It then enters the bulb, and is continued onwards in the corpus spongiosum as far as the glans penis, the erectile tissue of which parts it supplies. It anastomoses with its fellow of the opposite side and with the dorsal arteries of the penis. Whilst between the two layers of the triangular ligament the artery furnishes a branch to Cowper's gland of the corresponding side.

The **artery of the corpus cavernosum** is one of the two terminal branches of the internal pudic, and is somewhat larger than the dorsal artery of the penis, which is the other terminal branch. It arises about 1 inch below the subpubic angle, and immediately thereafter pierces the compressor urethræ muscle and the antero-inferior layer of the triangular ligament close to the ischio-pubic ramus. It then passes between the bone and the crus, and, entering the crus on its deep surface, it is continued onwards in the centre of the corpus cavernosum as far as the distal end of that body, the erectile tissue of which it supplies.

The **dorsal artery of the penis** is the continuation of the internal pudic. For a very short distance it lies between the two layers of the triangular ligament embedded in the compressor urethræ muscle, its course here being upwards. It then turns forwards, and, having pierced that muscle and the antero-inferior layer of the ligament very near its upper part, it ascends between the crus and the symphysis pubis. Its subsequent course is between the two layers of the suspensory ligament of the penis, and then along the dorsum of the organ, where it has the centrally-placed dorsal vein on its inner side and the dorsal nerve of the penis on its outer. On arriving at the neck of the penis it ends in branches for the supply of the glans and prepuce, where it anastomoses with its fellow of the opposite side and the arteries of the corpus spongiosum. In its course along the dorsum of the penis the artery gives off many branches, some of which supply the integument and anastomose with the superior external pudic of the common femoral, whilst others pierce the fibrous sheath of the corpus cavernosum to supply its erectile tissue, these latter anastomosing with the artery of the corpus cavernosum.

Varieties of the Internal Pudic Artery—1. **Trunk.**—The vessel is occasionally of small size, and may terminate in the artery of the bulb, or in the superficial perineal artery. In these cases an **accessory pudic artery** is present, which supplies the deficiencies. This vessel usually arises from the first or intrapelvic part of the internal pudic, though it may spring from an inferior

vesical artery. Its course is forwards along the side of the bladder, then along the side of the prostate gland to the triangular ligament of the urethra, which it pierces above the membranous part of the canal, and so reaches the root of the penis. The accessory pudic furnishes the artery of the corpus cavernosum and the dorsal artery of the penis, and in some cases the artery of the bulb.

2. **Artery of the Corpus Spongiosum (Artery of the Bulb).**—Sometimes two arteries are present on one side; sometimes the artery is absent on one side; and sometimes it is of very small size. A much more important variety of this artery affects its origin. It may arise from the fourth part of the internal pudic close to the base of the triangular ligament, and even from the third part at the front of the ischio-rectal fossa. In these cases the artery cannot escape division in the operation of lateral lithotomy. In other cases it may arise from an accessory pudic artery, when it will lie higher up and further forwards than usual.

3. **Dorsal Artery of the Penis.**—This vessel may arise from the obturator artery in the obturator canal, or from one of the external pudic branches of the common femoral artery.

Veins.—Lying in each compressor urethræ muscle there is a plexus of veins, which receives its tributaries from the corresponding corpus cavernosum and one half of the corpus spongiosum and bulb. The **internal pudic venæ comites** arise on either side from this plexus, and accompany the internal pudic artery as far back as the upper border of the spine of the ischium, one lying on either side of the vessel. Here they join to form one trunk, which enters the pelvis through the lower compartment of the great sacro-sciatic foramen, and terminates in the internal iliac vein. They receive as tributaries the transverse perineal, superficial perineal, and inferior hemorrhoidal veins, as well as a few veins from the gluteus maximus and external rotator muscles. The **inferior hemorrhoidal veins** take their origin in a plexus of veins which is situated on the outer surface of the external sphincter muscle. Having crossed the ischio-rectal fossa through its loose fat, and being ultimately reduced to two or three in number, they join the internal pudic venæ comites.

It is to be noted that, though there are two dorsal arteries, there is only one dorsal vein, which takes the following course: after leaving the dorsum of the penis it passes through an opening between the subpubic and transverse pelvic or perineal ligaments, where it communicates on either side with the venous plexus in each half of the compressor urethræ muscle. Having entered the cavity of the pelvis, it divides into two branches, right and left, which join the prostatic plexus of veins.

Lymphatics.—The **superficial lymphatics** of the perineum, as well as those of the anus and lower part of the anal canal, pass to the *inguinal glands*, which lie immediately below Poupart's ligament, whilst the **deep lymphatics** pass to the *internal iliac glands*.

Pudic Nerve.—The pudic nerve is one of the terminal branches of the sacral plexus, and derives its fibres from the ventral division of the second, the lower branch of the third, and the upper branch of the fourth sacral nerves, the majority of its fibres being derived from the lower branch of the third. Leaving the pelvis through the lower compartment of the great sacro-sciatic foramen, the nerve

crosses the back of the spine of the ischium, where it lies under cover of the gluteus maximus and on the inner side of the internal pudic vessels. It then passes through the small sacro-sciatic foramen, and so enters Alcock's canal in the outer wall of the ischio-rectal fossa. Immediately after doing so, it divides into three branches, namely, inferior hemorrhoidal, perineal, and dorsal nerve of the penis.

The **inferior hemorrhoidal nerve** passes inwards across the ischio-rectal fossa to the region of the anus, and is distributed to the external sphincter muscle and the integument which covers the ischio-rectal fossa.

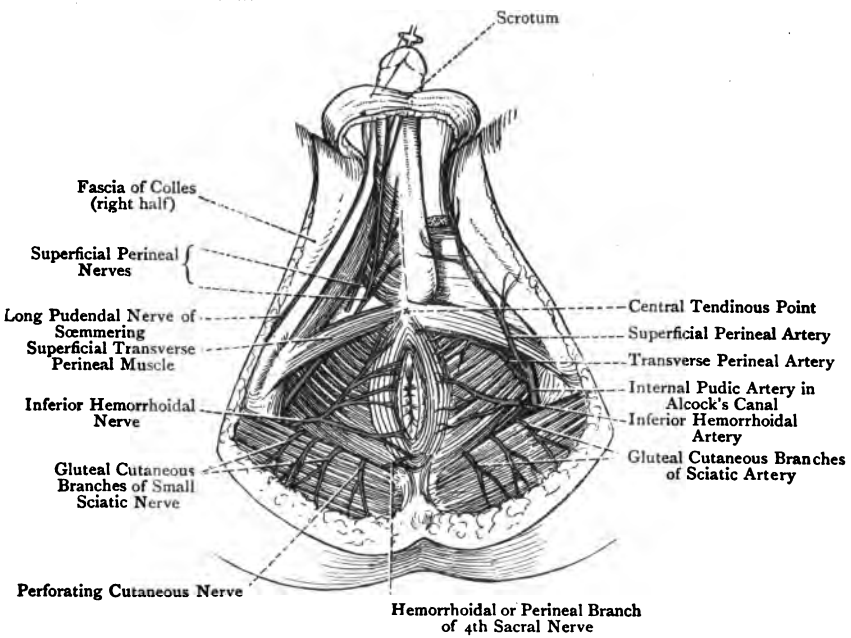
Scrotum
Fascia of Colles (right half)
Superficial Perineal Nerves
Long Pudendal Nerve of Sœmmering
Superficial Transverse Perineal Muscle
Inferior Hemorrhoidal Nerve
Gluteal Cutaneous Branches of Small Sciatic Nerve
Perforating Cutaneous Nerve
Central Tendinous Point
Superficial Perineal Artery
Transverse Perineal Artery
Internal Pudic Artery in Alcock's Canal
Inferior Hemorrhoidal Artery
Gluteal Cutaneous Branches of Sciatic Artery
Hemorrhoidal or Perineal Branch of 4th Sacral Nerve

FIG. 270.—DISSECTION OF THE MALE PERINEUM

(On the left side the bulbo-cavernosus has been removed, and the crus penis cut).

The **perineal nerve** is a large branch which passes forwards in Alcock's canal, being the lowest of its contents. It ultimately divides into superficial and deep branches.

The *superficial branches* are two in number, and are called the *external* or *posterior*, and *internal* or *anterior*, *superficial perineal nerves*. Both nerves, having emerged from Alcock's canal, pass forwards and pierce the base of the antero-inferior layer of the triangular ligament. They then run forwards with the superficial perineal artery under cover of the fascia of Colles, and on approach-

ing the back of the scrotum they divide into long slender branches, which supply the scrotal integument.

In the anterior division of the perineum the two superficial perineal nerves communicate freely, and are accompanied by the **long pudendal nerve of Sœmmering**, which is a branch of the small sciatic. This nerve, having pierced the fascia lata about 1 inch in front of the tuber ischii, passes inwards over the ischio-pubic ramus and through the fascia of Colles. It then runs forwards and inwards beneath that fascia to the scrotum, to take part in the supply of its integument, and it communicates with the external or posterior superficial perineal nerve.

The two superficial perineal nerves and the long pudendal nerve are known as the **long scrotal nerves.**

The *deep branch of the perineal nerve* furnishes offsets which, with one exception, are muscular in their distribution, and supply the anterior part of the external sphincter, the anterior part of the levator ani, the superficial transverse perineal, the ischio-cavernosus, and the bulbo-cavernosus. The non-muscular branch, called the nerve of the bulb, pierces the bulbo-cavernosus muscle and the wall of the bulb, to be distributed to the erectile tissue of the corpus spongiosum and the mucous membrane of the spongy part of the urethra.

The **dorsal nerve of the penis** is at first contained in Alcock's canal, where it lies above the internal pudic vessels. Having emerged from that canal, it pierces the postero-superior layer of the triangular ligament near its base. It then passes forwards and upwards, with the fourth part of the internal pudic artery, between the two layers of the triangular ligament, in which situation it lies on the outer side of the internal pudic vessels, and close to the ischio-pubic ramus, being embedded in the compressor urethræ muscle. Its subsequent course is similar to that of the dorsal artery of the penis, which it accompanies. On the dorsum of the penis, where it lies external to the dorsal artery, it is continued as far as the glans, where it ends in branches for the glans and prepuce. As the nerve lies between the two layers of the triangular ligament, it gives branches to the compressor urethræ muscle, and it also furnishes the nerve of the corpus cavernosum. This latter nerve, having pierced the compressor urethræ and antero-inferior layer of the triangular ligament, enters the crus, and is continued forwards in the corpus cavernosum to supply the erectile tissue of these parts. As the nerve passes along the dorsum of the penis, it supplies numerous branches to the integument of that organ.

Structures divided in Left Lateral Lithotomy. — The structures divided in this operation are as follows: (1) the skin; (2) the subcutaneous layer of the superficial fascia; (3) the deep layer of the superficial fascia or the fascia of Colles; (4) the transverse perineal vessels; (5) the superficial transverse perineal muscle; (6) the inferior hemorrhoidal vessels and nerve; (7) the basal part of the antero-inferior layer of the triangular ligament; (8) the compressor urethræ muscle and the plexus of veins embedded in it; (9) the

membranous part of the urethra; (10) the postero-superior layer of the triangular ligament; (11) the anterior fibres of the levator ani muscle; (12) a portion of the left lateral lobe of the prostate gland, with its capsule, and some of the veins of the prostatic plexus; and (13) the neck of the bladder.

Structures to be avoided.—The structures to be avoided are as follows: (1) the rectum; (2) the internal pudic vessels as they lie in Alcock's canal; (3) the artery of the bulb; and (4) the common ejaculatory duct.

FEMALE PERINEUM.

The female perineum is divided into three regions—uro-genital, perineum proper, and ischio-rectal. The uro-genital division is situated at the anterior part, and comprises the pudendum and uro-genital cleft. The perineum proper is situated between the posterior part of the uro-genital cleft and the anus. The ischio-rectal division is situated as in the male.

Uro-genital Division.

The uro-genital division contains the external uro-genital organs. These collectively constitute the **pudendum**, and comprise the following parts: the mons Veneris; labia majora; labia minora, or nymphæ; clitoris; vestibule; meatus urinarius; vaginal orifice, including the hymen, or the carunculæ myrtiformes; frænulum pudendi; fossa navicularis; bulbi vestibuli; and glands of Bartholin or of Duverney.

The **mons Veneris** is an eminence situated in front of and above the upper part of the symphysis pubis. It is produced by a collection of adipose tissue, the skin over which is more or less freely provided with hair after the age of puberty.

The **labia majora** are two thick, round folds of integument, which are directed from before backwards, with a slight inclination downwards. The length of each is about 3 inches. Posteriorly they become thin, and join each other at the anterior part of the perineum proper, about 1 inch in front of the anus. The junction receives the name of the **posterior commissure**, and is somewhat pointed. Anteriorly they retain their thick, round character, and here also they join and become continuous with the mons Veneris. This latter junction is called the **anterior commissure.** Each labium majus has two surfaces, outer and inner. The skin covering the outer convex surface is somewhat dark in colour, like that of the scrotum, and contains numerous sebaceous glands of large size. It is also more or less freely provided with hair after the age of puberty, except towards the posterior part. The inner flat surface forms the lateral boundary of the uro-genital cleft, and touches that of the opposite side. The skin covering this surface is smooth and free from hair, and presents the openings of the ducts of sebaceous glands. Each labium majus contains adipose and areolar tissues, and a small amount of dartos tissue. The round ligament of the

uterus of each side loses itself in this labium, and the fasciæ of Camper and of Scarpa of the lower part of the anterior abdominal wall of each side also enter it. The fissure between these labia is called the **uro-genital cleft** or **rima pudendi**, and is almost horizontal, its direction being antero-posterior. The blood-supply and nerve-supply of the labia majora correspond with those of the scrotum.

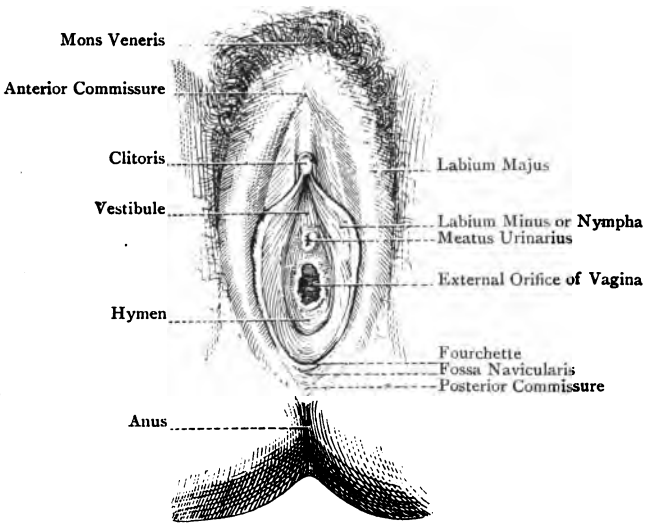

FIG. 271.—THE EXTERNAL GENITAL ORGANS OF THE FEMALE.

The **labia minora**, or **nymphæ**, are two narrow, more or less pendulous folds of integument, which are situated in the uro-genital space, each lying internal to the corresponding labium majus. They become continuous with each other anteriorly, in the region of the clitoris, a short distance from the anterior commissure, in a manner to be presently described. From this point they diverge as they pass backwards, and so form the lateral boundaries of the space called the vestibule. Each terminates posteriorly by blending with the inner surface of the corresponding labium majus, or in some cases by becoming continuous with the frænulum pudendi. Each labium minus has two surfaces, outer and inner, and two borders, superior and inferior. The outer surface is in contact with the inner surface of the labium majus of the same side, and the inner surface touches that of the opposite nympha. Each surface is covered by a modified form of skin, that on the inner surface being extremely delicate, and being somewhat like mucous membrane. The true mucous membrane, however, only commences at the inner side of the base or superior attached border of the labium minus. The labia minora, previous to their union anteriorly,

divide each into two laminæ. The upper and larger lamina passes over the clitoris, and becomes continuous with that of the opposite side, thus forming a cap for that organ, called the **præputium clitoridis.** The lower and smaller lamina passes below the clitoris, where it also becomes continuous with that of the opposite side. At the line of junction of the two lower laminæ they are attached to the under surface of the clitoris, thus forming the **frænulum clitoridis.** The labia minora are destitute of both hair and fat, but they contain sebaceous glands. They sometimes attain a large degree of development, in which cases they project through the uro-genital fissure. In some African women they become so much developed as to reach down to the knees. When this occurs they form what has been called the apron of Hottentots. The labia minora are homologous with the floor of the spongy part of the urethra and the integument of the under surface of the penis and prepuce in the male.

Development of the Labia Majora and Labia Minora.—The anterior part of the cloacal fossa in the female forms the **uro-genital space,** and the margins or lips of this space become prominent and give rise to the **outer genital folds.** At the posterior (lower) part of the uro-genital space there is the **uro-genital cleft,** which receives the external orifices of the urethra and vagina. The lips of this cleft form two other folds, called the **inner genital folds.** The *outer genital folds* form the **labia majora,** and the *inner genital folds* give rise to the **labia minora.** In the male the anterior part of the cloacal fossa (uro-genital furrow) is closed over by the meeting and union of its lips to form the spongy portion of the urethra. The *genital folds,* which correspond with the *outer* genital folds in the female, coalesce in a median raphé, and so give rise to the **scrotum,** which, therefore, corresponds to the labia majora in the female.

The **clitoris** is situated in the uro-genital space a little behind the anterior commissure, and is composed of two corpora cavernosa and a glans. Each **corpus cavernosum** is attached by means of a *crus* to the anterior everted lip of the inner border of the ischio-pubic ramus, the crus being covered by the ischio-cavernosus or erector clitoridis muscle, and lying superficial to the antero-inferior layer of the triangular ligament. The two corpora cavernosa unite by their inner flattened surfaces, and so form the body of the clitoris, which is about 1½ inches long. The septum, which is interposed at the line of junction of the corpora cavernosa, is incomplete, and is called the *septum pectiniforme.* The dorsal surface of the clitoris at its upper end is attached to the front of the symphysis pubis by a small suspensory ligament, and the distal end of the organ is capped by an imperforate glans. The *glans,* which caps the corpora cavernosa, is composed of erectile tissue, and is extremely sensitive. It is provided with a prepuce and a frænulum, both of which are continuous with the labia minora. The organ is composed of erectile tissue.

The clitoris is the homologue of the penis, from which it differs in the following respects : (1) the only part of a corpus spongiosum which it possesses is the glans (the part of the corpus spongiosum

of the male which lies between the bulb and the glans penis being represented in the female by the *pars intermedia* of the bulbi vestibuli); (2) it does not contain the female urethra; and (3) its component parts are much smaller than those of the penis. In reality the clitoris is a diminutive penis, minus the corpus spongiosum and the urethra.

The **vestibule** is the space which is enclosed by the labia minora, and is so called because it is the 'porch' of the vagina. It is triangular, the apex, which is in front, being formed by the glans clitoridis, the lateral boundaries by the labia minora, and the base, which is directed backwards, by an imaginary line passing transversely in front of the external orifice of the vagina and behind the meatus urinarius. It is about 1 inch in length, and presents a smooth surface formed by mucous membrane, which is covered by stratified squamous epithelium. At its posterior extremity, in the middle line, and immediately in front of the external orifice of the vagina, there is a slight prominence, with somewhat irregular margins. Upon this prominence the **meatus urinarius** is situated at a point 1 inch behind the clitoris. The irregular prominence serves as a guide to this opening.

The vestibule represents the remains of the uro-genital sinus.

The **external orifice of the vagina** is situated immediately behind the vestibule. It is an antero-posterior cleft, having an elliptical shape when partially dilated. The portion of the vagina close above it is the narrowest part of the passage. For the description of the vagina, see p. 832.

The **hymen** in its normal condition is a thin semilunar fold of mucous membrane which is stretched across the posterior third, or half, of the external orifice of the vagina. Its concave border, which is free, is directed forwards and upwards. Sometimes the hymen completely surrounds the circumference of the orifice, an aperture being left in its centre. In other cases it stretches over the entire opening, but is perforated by apertures which give it a cribriform appearance. In rare cases it is an entire membrane, completely shutting off the vaginal canal from the uro-genital space, and it is then spoken of as an imperforate hymen. In some cases, even in the virgin, it is entirely absent.

The hymen begins to appear about the fifth month of intra-uterine life as a fold of the mucous membrane at the point where the vagina opens into the uro-genital sinus.

The **carunculæ myrtiformes** are small elevations which represent the remains of the hymen after its disappearance. Though called *carunculæ* (fleshy), they are really mucous excrescences.

The **fourchette,** or **frænulum pudendi,** is a crescentic fold of the uro-genital lining membrane which is situated a little in front of the posterior commissure, and it is best marked in early life.

The **fossa navicularis** is a small depression which lies between the posterior commissure and the fourchette.

The **bulbi vestibuli** are two ovoid masses of erectile tissue 1 inch in length, which are situated on either side of the external orifice of the vagina and vestibule beneath the mucous membrane. Each bulb is covered by a delicate fibrous capsule derived from the antero-inferior layer of the triangular ligament, superficial to which the bulb of either side lies. The outer surface is convex, and is covered by one half of the sphincter vaginæ muscle. The inner surface is slightly concave, and is covered by the vaginal mucous membrane. Posteriorly the bulbs diverge, and anteriorly, having become narrow, they pass upwards and forwards, and ultimately meet in the middle line, where they are attached to the antero-

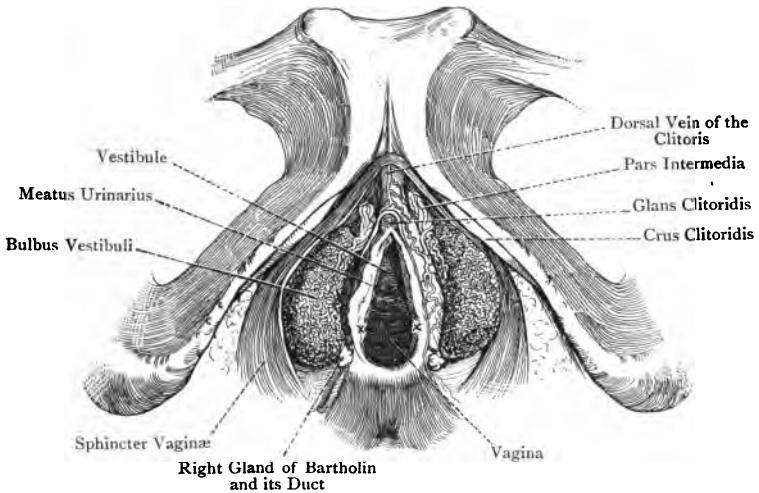

FIG. 272.—DISSECTION SHOWING THE BULBI VESTIBULI AND GLANDS OF BARTHOLIN (MODIFIED FROM KOBELT)

(The cross on either side of the Vaginal Orifice shows the position of the opening of the Duct of Bartholin's Gland).

inferior layer of the triangular ligament. In front of the bulbs there is a plexus of veins which is continuous behind with their erectile tissue, and in front with that of the glans clitoridis. This plexus of veins is known as the **pars intermedia of Kobelt.** It receives its veins from the labia minora, and its blood is conveyed into the vaginal plexus.

The bulbi vestibuli, together, represent the bulb of the male urethra, which latter presents on its under surface a faint groove in the middle line, indicating a tendency to a bipartite division. The pars intermedia of Kobelt is regarded as representing that part of the male corpus spongiosum which extends from the bulb to the glans penis.

The **glands of Bartholin** or **of Duverney** belong to the class of racemose or acino-tubular glands. They are two in number, right and left, and each resembles a small bean. They lie on either side of the external orifice of the vagina towards its back part, immediately behind the posterior extremities of the bulbi vestibuli, and superficial to the base of the triangular ligament. The duct of each gland is about ¾ inch long, and opens in the angle between the attached border of the nympha posteriorly and the hymen or its remains, close to the centre of the margin of the vaginal orifice.

These glands are homologous with the glands of Cowper, and their structure is similar.

The glands of Bartholin are developed from the lining epithelium of the uro-genital sinus.

The external uro-genital organs of the female have received the name of **vulva**. As this word, however, literally signifies 'a covering,' it is strictly applicable only to the labia majora, which by their approximation form a covering for the uro-genital space and its contents.

Perineum Proper.

The perineum proper is the region which lies between the anus and the posterior commissure, and it presents a raphé in the middle line. It is in this division that the perineal body is situated, as well as the central tendinous point. The latter, being similar to that of the male, requires no special description.

Perineal Body.—This body is peculiar to the female perineum. It is situated between the anus and the posterior commissure, and it may be regarded as a deep expansion of the central tendinous point. It is triangular, and is about 1½ inches in breadth. It is bounded *in front* by the posterior wall of the vagina, *behind* by the anterior wall of the anal canal, and *inferiorly* by the integument. The perineal body is produced by a thickening of connective tissue, with a free admixture of elastic tissue, and a few muscular fibres derived from the external sphincter, levatores ani, and sphincter vaginæ muscles. It serves as a support to the posterior wall of the vagina. During parturition it becomes greatly stretched, but its elastic tissue usually guards it against rupture.

Triangular Ligament.—The triangular ligament resembles that of the male in being composed of two layers, antero-inferior and postero-superior.

The **antero-inferior layer**, on account of the greater width of the subpubic arch in the female, is broader than in the male, though it is more indefinite on account of its being pierced by the vagina. It is attached at either side to the inner border of the ischio-pubic ramus, and superiorly to the transverse pelvic or perineal ligament. In the middle line, where it is pierced by the vagina, it blends with the wall of that canal. Its base is joined by a somewhat indefinite layer of fascia representing the fascia of

Colles in the male, and by the postero-superior layer. The openings in the antero-inferior layer are similar to those in the male, with this exception, that the ducts of the glands of Bartholin do not pierce it as the ducts of the glands of Cowper do in the male, the glands of Bartholin being situated superficial to this layer. The urethral opening is situated 1 inch below the symphysis pubis. The opening for the vagina, which is of large size, lies below the urethral orifice, from which it is separated by a few fibres. The openings for the arteries of the bulbi vestibuli are situated one on either side of the vaginal opening. The openings for the artery of the corpus cavernosum clitoridis, for the dorsal artery and nerve of the clitoris, and for the superficial perineal vessels and nerves, all of each side, are situated as in the male.

It is to be noted that the dorsal vein of the clitoris, like the corresponding vessel in the male, passes between the subpubic and transverse pelvic or perineal ligaments.

The **postero-superior layer** is similar to the corresponding layer in the male, and it presents openings for the urethra, vagina, and internal pudic vessels and pudic nerves of each side.

Ischio-rectal Division.

The chief characters of the ischio-rectal division in the female are as follows: the aperture of the anus is somewhat nearer the coccyx than in the male, the distance between the ischial tuberosities is greater than in the male, and the ischio-rectal fossæ are wider and shallower than in the male.

Muscles.—The muscles of the female perineum, as compared with those of the male, present certain differences.

Levatores Ani.—The anterior fibres of these muscles embrace the vagina instead of the prostate gland, as in the male.

Ischio-cavernosus (erector clitoridis).—This muscle replaces the erector penis, and is of small size.

Bulbo-cavernosus or **Sphincter Vaginæ.**—This muscle arises from the central tendinous point, where it meets the external sphincter and superficial transverse perineal muscles. It then passes forwards and divides into two symmetrical parts which surround the vaginal orifice and vestibule, each part closely embracing the outer surface of the corresponding bulbus vestibuli. Anteriorly the two parts become very narrow, and each is inserted into the fibrous sheath of the corpus cavernosum. A few fibres are here detached to be inserted into a tendinous expansion on the dorsum of the clitoris covering the dorsal vein, which vessel would be thereby compressed when the muscle is in action. Some of the inner fibres of the sphincter vaginæ are inserted into the mucous membrane of the vestibule.

The sphincter vaginæ is homologous with the bulbo-cavernosi in the male.

Compressor or **Constrictor Urethræ.**—This muscle, as in the male, lies between the two layers of the triangular ligament. It is

attached, on either side, to the inner margin of the ischio-pubic ramus, and in the middle line it is almost completely divided into two parts by the vagina. The anterior part passes transversely across the subpubic arch in front of the urethra, whilst the posterior and larger part passes inwards, partly transversely and partly obliquely, to blend with the vaginal wall.

The external sphincter and superficial transverse perineal muscles are similar to those in the male.

Internal Pudic Artery.—This vessel is of smaller size than in the male, but it takes a similar course. The difference, therefore, in the two sexes affects chiefly the branches of the artery.

The **superficial perineal artery** is larger than in the male, and is distributed to the labium majus.

The **artery of the bulb** is of comparatively small size, and is distributed to the bulbus vestibuli.

The **artery of the corpus cavernosum clitoridis,** having pierced the antero-inferior layer of the triangular ligament, enters the crus clitoridis, and is then continued onwards in the centre of the corpus cavernosum.

The **dorsal artery of the clitoris,** like the preceding, is comparatively small in size. Having pierced the antero-inferior layer of the triangular ligament, it passes between the crura clitoridis, and also between the two layers of the suspensory ligament of the clitoris. It is then continued along the dorsum of that organ as far as the glans, having the dorsal vein of the clitoris on its inner side, and the dorsal nerve of the clitoris on its outer side. On reaching the glans, it divides into branches for the supply of the glans and its prepuce. As it passes along the dorsum of the clitoris it gives off several branches, which enter the corpus cavernosum by piercing its fibrous sheath.

The **veins** of the female perineum are so similar to those in the male as not to require any special description. An exception, however, has to be made in the case of the **dorsal vein of the clitoris.** This vein is formed by branches which return the blood from the glans and prepuce, and also to a certain extent from the corpora cavernosa. It passes backwards in the groove between the corpora cavernosa, where it has on either side of it the dorsal artery, and external to this the dorsal nerve, of the clitoris. In this part of its course it receives tributaries from the corpora cavernosa. On reaching the root of the organ it passes between the two layers of the suspensory ligament of the clitoris, and then between the subpubic and transverse pelvic or perineal ligaments, and so it enters the pelvic cavity, where it terminates in the plexus of veins at the neck of the bladder.

Lymphatics.—The lymphatics of the labia majora, the superficial lymphatics of the clitoris, including those of its glans, and the lymphatics of the *lower third* of the vagina and of the urethra terminate in the *inguinal glands*, which lie immediately below Poupart's ligament. The lymphatics of the *upper two-thirds* of

the vagina terminate in the *internal iliac glands*, and the deep lymphatics of the corpora cavernosa clitoridis, having accompanied the dorsal vein of the clitoris, also terminate in the internal iliac glands.

The **pudic nerve** and its branches are similar to those in the male, the superficial perineal nerves being distributed to the labia majora.

ABDOMINAL WALL.

Landmarks.—The position of the **linea alba** is indicated by the mid-abdominal groove, which extends from the ensiform process of the sternum to the umbilicus, and the mid-abdominal line, which extends from the umbilicus to the upper part of the symphysis pubis. After removal of the integument the linea alba presents a dense white appearance, and is slightly depressed below the level of the adjacent surfaces. It is produced by the decussation of the aponeuroses of the abdominal muscles of opposite sides, except the recti, and it is divided into two parts, supra-umbilical and infra-umbilical. The supra-umbilical part is about $\frac{1}{4}$ inch broad, the recti being here separated to that extent. The infra-umbilical part is only about $\frac{1}{8}$ inch wide on account of the approximation of the recti in this situation. Over the whole extent of its posterior or abdominal surface it is invested by the parietal peritoneum, unless in cases of abnormal distension of the bladder, when the peritoneum is stripped from the lower part to an extent corresponding with the height to which the distended bladder ascends. The anterior abdominal wall is thinner and less vascular along the linea alba than at any other part. This line is therefore selected for such operations as suprapubic lithotomy, tapping a distended bladder above the symphysis pubis, and ovariotomy.

The structures which are divided in opening the abdominal cavity along the linea alba are as follows: the integument, the decussating fibres of the aponeuroses of opposite sides, fascia transversalis, subperitoneal areolar tissue, and parietal peritoneum. There are no bloodvessels of any importance in this situation.

The posterior aspect of the linea alba has important visceral relations. The left lobe of the liver lies behind it for about 2 inches below the ensiform process of the sternum. The relation of the stomach to it is variable. When the viscus is moderately distended it lies behind the linea alba below the margin of the liver. In the empty condition, however, it recedes from the linea alba, and this gives rise superficially to the *epigastric depression*, or *scrobiculus cordis* ('small trench of the heart'). The transverse colon, covered by the great omentum, as it crosses from right to left, usually lies behind the linea alba just above the umbilicus. The coils of the jejunum and ileum, also covered by the great omentum, lie behind it below the umbilicus.

In young persons the upper part of the bladder, being extra-pelvic, lies behind the lowest part of the linea alba. In adults the upper part of that viscus, when abnormally distended, also lies behind the lowest part of this line.

The **umbilicus** takes the form of a cicatricial depression which is situated in the linea alba at the junction of the upper three-fifths and lower two-fifths. As seen from before it is irregularly circular, the skin being more or less puckered according to the state of distension of the abdomen. When viewed from behind it is smaller in size, and its long measurement lies transversely. Besides cicatricial tissue and fat, the lower part of it contains the upper ends of the urachus and obliterated hypogastric arteries, whilst the upper part is occupied by part of the obliterated umbilical vein. The upper part is weaker than the lower. The umbilicus is on the same horizonal plane as the disc between the bodies of the third and fourth lumbar vertebræ.

During intra-uterine life the umbilicus is an opening by which the hypogastric arteries leave the abdomen of the fœtus on their way to the placenta, and by which the umbilical vein, on its way from the placenta, enters the abdomen. A few days after birth, however, the opening becomes permanently closed.

The **lineæ semilunares** coincide with the outer borders of the recti abdominis. The position of each is indicated by a line drawn from the lowest part of the eighth costal cartilage to the pubic spine. This line is curved, with the convexity outwards, and at the level of the umbilicus it is about 3 inches from it. Over the upper three-fourths of the rectus abdominis it indicates the splitting of the aponeurosis of the internal oblique into two laminæ, which encase that extent of the muscle in a sheath. Over the lower fourth it indicates where the aponeuroses of the external oblique and internal oblique and the anterior aponeurosis of the transversalis abdominis pass in front of the rectus.

The **lineæ transversæ** are usually three in number, on either side. They are tendinous intersections or inscriptions which cross the rectus in the following situations: one at the level of the umbilicus, one at the level of the lower part of the ensiform process of the sternum, and one about midway between these two. The positions of the lineæ transversæ are indicated by three faint grooves. The anterior wall of the sheath of the rectus is closely bound down to the tendinous intersections, and so each muscle above the level of the umbilicus is mapped out into two quadrangular areas, and the interior of the sheath, anterior to the muscle, is also divided into two distinct compartments. An abscess may form in one or other of these compartments, or there may be a spasmodic contraction of one or other of these quadrangular areas of the muscle, a condition in each case which would necessarily have a circumscribed limit, and might lead to error in diagnosing affections really having their seat within the abdominal cavity.

The **spino-umbilical lines** are two in number, right and left,

and each extends from the anterior superior iliac spine to the umbilicus.

The **anterior superior spinous process of the ilium** is situated at the anterior extremity of the iliac crest, and, being very superficial, it can be readily felt. It is on the same level with that of the opposite side, and therefore a line connecting the two should be quite horizontal. The plane of this interspinous line is rather lower than the promontory of the sacrum. The anterior superior iliac spine is the point from which the measurement of the lower limb is taken, the other point being the internal malleolus. This spine is also a good ready guide to the position of the great trochanter, which is situated about 4 inches below it, and about 4½ inches behind a line let fall vertically from it.

The **pubic spine** is situated at the lower and inner part of the anterior abdominal wall about 1½ inches outside the upper part of the symphysis pubis. It is sometimes a sharp-pointed process, and then it can readily be felt beneath the integument. In most persons, however, it takes the form of a more or less indistinct tubercle, and cannot readily be made out. In such cases the scrotal integument may be invaginated with the finger, and so the adipose tissue raised from over the spine. If it cannot be felt in this way the thigh should be well abducted to render prominent the adductor longus muscle, the tendon of origin of which will serve as a guide to the spine, which lies above and to the outer side of it. The pubic spine is the guide to the external abdominal ring, the crural or femoral ring, and the saphenous opening. The **external abdominal ring** is situated immediately above, and to the outer side of, the pubic spine. In exploring the ring the best way to proceed is to invaginate the scrotal integument, and carry the examining finger up the inner side of the spermatic cord, when the ring will be reached. In normal circumstances it should admit the point of the little finger. In making this examination the spermatic cord is readily felt, and the vas deferens can be distinguished as a firm cord-like structure lying at its back part, and easily separable from the other constituents of the cord. In the female the round ligament of the uterus takes the place of the spermatic cord, but, being a very ill-defined structure, it usually escapes detection. The **crural** or **femoral ring** is situated fully 1 inch external to the pubic spine in a line drawn transversely outwards from that spine across the front of the thigh. The **saphenous opening** is situated below, and a little external to, the pubic spine.

The **pubic crest** extends transversely inwards for about 1½ inches from the pubic spine, and it terminates in the pubic angle which surmounts the internal surface of the pubic body, and is usually a rudimentary tubercle. The crest may be felt with the finger as the external abdominal ring, of which it forms the base, is being explored.

Poupart's ligament can be felt as a tense band, especially when the thigh is extended, abducted, and rotated outwards,

passing between the anterior superior iliac spine and the pubic spine.

The **internal abdominal ring** is situated midway between the symphysis pubis and the anterior superior iliac spine, and ½ inch above Poupart's ligament.

The **inguinal canal** extends obliquely downwards, forwards, and inwards from the internal to the external abdominal ring, and is situated immediately above the inner half of Poupart's ligament.

Topography of Arteries, Triangles, and Iliac Fossæ.—The **bifurcation of the aorta** into right and left common iliac arteries usually takes place opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line. The position of the bifurcation is indicated in one of two ways: (1) a point fully 1 inch below the umbilicus and a finger's breadth to the left of the linea alba pretty nearly corresponds with the point of bifurcation; (2) a more definite guide is a point in the line which connects the highest parts of the iliac crests a finger's breadth to the left of where it intersects the linea alba.

The **common and external iliac arteries** are indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the point corresponding to the bifurcation of the aorta. This line should be slightly curved, with the convexity directed outwards. Its upper 2 inches indicate the course of the common iliac artery, and the remainder represents the external iliac.

The **deep epigastric artery,** in its first or oblique part, is indicated by a line drawn from the inner border of the internal abdominal ring to the outer border of the rectus abdominis at a point midway between the upper border of the symphysis pubis and the umbilicus. The subsequent course of the vessel is represented by a line corresponding to the centre of the rectus abdominis, and reaching to a point about 2 inches above the umbilicus. This latter line is about 1½ inches distant from the linea alba.

The **triangle of Hesselbach** is situated on the inner side of the first or oblique part of the deep epigastric artery, and above the inner half of Poupart's ligament.

The **triangle of Petit** is situated immediately above the centre of the iliac crest. In this region a lumbar hernia may protrude, and a lumbar abscess may come to the surface at this point.

The **right iliac fossa** contains the terminal part of the ileum, the cæcum, the ileo-cæcal valve, and the vermiform appendix in part.

The **left iliac fossa** contains the iliac colon.

McBurney's point is situated in the right spino-umbilical line between 1½ and 2 inches from the anterior superior iliac spine. According to McBurney it corresponds very accurately in the living subject to the base of the vermiform appendix. Practically it coincides with the centre of the right iliac fossa.

Monro's point is situated at the centre of the spino-umbilical line. Its distance from the anterior superior iliac spine is 2·6 inches.

Upon the right side McBurney's point and Monro's point very nearly coincide. Both of these points are now regarded as indicating approximately the situation of the ileo-cæcal valve, and not the base of the vermiform appendix. The guide to the base or opening of the appendix is a point on an average rather more than 1 inch below the ileo-cæcal valve—that is to say, the base or opening of the vermiform appendix is rather more than 1 inch below McBurney's point.*

Anterior Abdominal Fasciæ.—The **superficial fascia** of the anterior wall of the abdomen, from Poupart's ligament to a line drawn transversely from the anterior superior iliac spine to the linea alba, resembles the superficial fascia of the uro-genital division of the perineum in being divisible into two layers. The layer immediately beneath the skin is called the subcutaneous layer or fascia of Camper, and the other layer is called the deep layer or fascia of Scarpa.

The *subcutaneous layer* or **fascia of Camper** is composed of areolar tissue containing adipose tissue in its meshes. When traced upwards it blends with the deep layer above the level of the line connecting the anterior superior iliac spine with the linea alba. When followed inwards it is continuous with the corresponding layer of the opposite side. In a downward direction it is freely continuous over Poupart's ligament with the subcutaneous layer of the superficial fascia of the front of the thigh. When traced downwards and inwards it passes along the spermatic cord into the scrotal wall and over the penis, in which situations, more especially the former, it contains involuntary muscular fibres, which replace its adipose tissue, and so, with the deep layer which it here joins, it forms the *tunica dartos*. In the female Camper's fascia passes along the round ligament of the uterus into the labium majus.

The *deep layer* or **fascia of Scarpa** is a strong membrane which contains yellow elastic tissue. It is separated from Camper's fascia by the superficial epigastric vessels, and, in the region of Poupart's ligament, by the inguinal glands. Its deep aspect is loosely connected by areolar tissue to the subjacent aponeurosis of the external oblique muscle. Superiorly, above the line connecting the anterior superior iliac spine with the linea alba, it blends with Camper's fascia. At the middle line it is firmly bound down by fibrous bands to the linea alba. Inferiorly it blends with the inner part of Poupart's ligament, but external to this it passes over that ligament, to which it is bound by fibrous bands, and immediately thereafter it becomes incorporated with the fascia lata of the thigh. When traced downwards and inwards it passes along the spermatic cord into the scrotal wall, and over the penis. In the former situation it forms, along with the subcutaneous layer, the *tunica dartos*. In the female Scarpa's

* Sir Frederick Treves, based upon observations made by Dr. C. Addison and Dr. Arthur Keith.

fascia passes along the round ligament of the uterus into the labium majus.

The fascia of Camper is continuous, through the tunica dartos, with the subcutaneous layer of the superficial fascia of the uro-

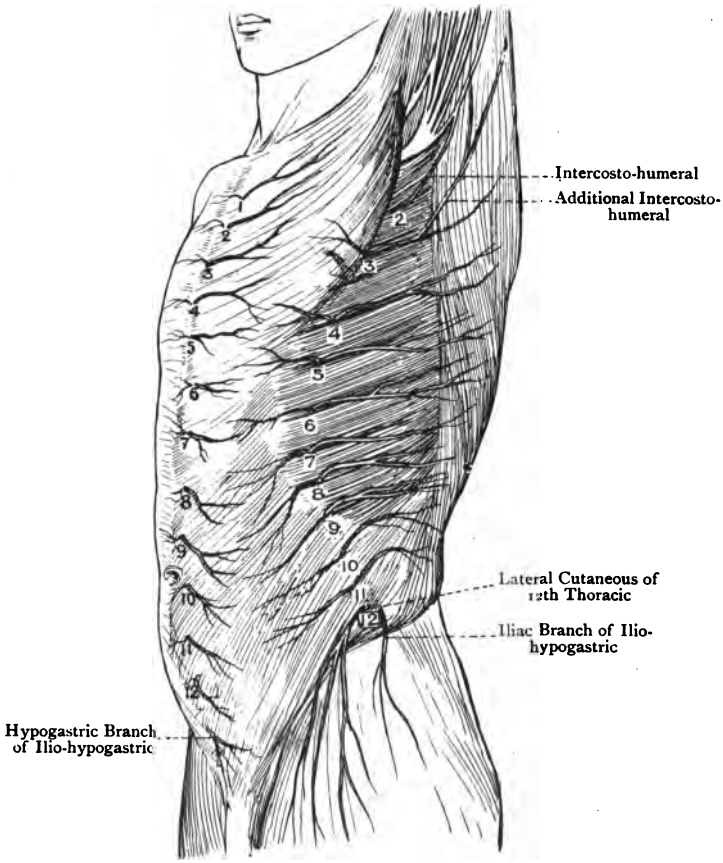

FIG. 273.—CUTANEOUS NERVES OF THE TRUNK (ANTERO-LATERAL VIEW) (AFTER HENLE).

1-12, Anterior Cutaneous; 2-12, Lateral Cutaneous.

genital division of the perineum, and the fascia of Scarpa is similarly continuous with the deep layer of the superficial fascia, or the fascia of Colles, of that division.

The disposition of Scarpa's fascia at the line of the groin explains why, in cases of extravasation of urine beneath Colles's fascia, the urine, when it reaches the anterior abdominal wall, does not pass

downwards to the front of the thigh, but takes an upward course.

The fascia of Scarpa represents the *tunica abdominalis* of quadrupeds, which is composed almost entirely of yellow elastic tissue, and serves as an important adjunct to the abdominal parietes.

The **deep fascia** resembles that in other parts of the body in being membranous. Laterally, where the external oblique is fleshy, this fascia is well marked, but, as it approaches the confines of the aponeurosis of that muscle, it becomes very delicate, and ultimately disappears. Over the external oblique aponeurosis, therefore, there is really no deep fascia properly so called, so that the deep layer of the superficial fascia or fascia of Scarpa lies directly upon the external oblique aponeurosis, to which it is loosely connected by areolar tissue.

Cutaneous Nerves. — The **anterior cutaneous nerves** are the terminal branches of the lower five intercostal nerves and of the anterior primary division of the twelfth thoracic nerve (subcostal nerve). Having emerged through the anterior wall of the sheath of the rectus abdominis in a straggling manner, they give a few twigs inwards, and then turn outwards to supply the anterior abdominal integument, in which they communicate with the anterior branches of the lateral cutaneous nerves.

The **hypogastric branch of ilio-hypogastric nerve** pierces the external oblique aponeurosis about 1 inch above the external abdominal ring, and is distributed to the integument of the suprapubic region. It is serially continuous with the anterior cutaneous nerves.

The skin below the ensiform process is supplied by the seventh thoracic nerve; that on a level with the umbilicus by the tenth thoracic; and that over the lower half of the infra-umbilical region by the twelfth thoracic, and the ilio-hypogastric.

The **lateral cutaneous nerves** are branches of the lower five intercostal nerves. Having emerged between the serrations of the external oblique muscle in the mid-axillary line, each divides into an anterior and a posterior branch. The *posterior branch* turns backwards to supply the integument over the lower part of the back. The *anterior branch* passes forwards to supply the anterior abdominal integument, in which it communicates with an anterior cutaneous nerve.

Cutaneous Arteries.—The **superior or superficial external pudic artery** arises from the common femoral about ¾ inch below Poupart's ligament, after which it pierces the crural sheath and cribriform fascia. Having emerged through the saphenous opening, it passes inwards and upwards over the spermatic cord, or round ligament of the uterus, according to the sex, to be distributed to the integument of the suprapubic region, the adjacent portion of the scrotum in the male and the labium majus in the female, and the dorsum of the penis by a branch which extends as far as the prepuce, lying external to the dorsalis penis artery. The vessel in its course gives branches to the pubic glands, the deep femoral glands, and the coverings of the spermatic cord, or of the round ligament of the uterus. It anasto-

moses with the following arteries: (*a*) the cremasteric branch of the deep epigastric, in crossing the spermatic cord, that branch being represented in the female by the artery of the round ligament of the uterus; (*b*) its fellow of the opposite side; (*c*) the inferior or deep external pudic; and (*d*) the dorsalis penis.

The venæ comites of this artery terminate in one vessel which joins the long saphenous vein.

The **superficial epigastric artery** arises from the common femoral about ½ inch below Poupart's ligament. Having pierced the crural sheath and cribriform fascia, or the outer border of the saphenous opening, it turns upwards over Poupart's ligament a little to the inner side of the centre, and then ascends in the abdominal integument as high as the level of the umbilicus. As it turns upwards it supplies branches to the inguinal glands, and on the abdominal wall it anastomoses with branches of the deep epigastric artery.

There are at first two venæ comites with this artery, but these eventually join to form one vessel which terminates in the long saphenous vein. The radicles of these venæ comites communicate with the following vessels: the parumbilical veins in the region of the umbilicus, which lie on the surface of the round ligament of the liver, and communicate with the branches of the vena portæ; the inferior or long thoracic and subscapular veins, upon the side of the thorax, which are tributaries of the axillary vein; and the superior epigastric veins, which are tributaries of the internal mammary veins. In the superficial epigastric vein and its tributaries the blood can flow in either direction. The anastomoses of the tributaries of the vein explain why they become engorged in cases of portal obstruction and obstruction of the inferior vena cava.

The **superficial circumflex iliac artery** often arises in common with the superficial epigastric from the common femoral about ½ inch below Poupart's ligament. Having pierced the crural sheath and the outer border of the saphenous opening, it passes outwards below the outer part of Poupart's ligament to the anterior part of the iliac crest, where it is distributed to the adjacent abdominal integument. In its course it gives branches to the iliacus and sartorius muscles and the outer inguinal glands, and it anastomoses with (*a*) the deep circumflex iliac of the external iliac, and (*b*) the gluteal of the internal iliac.

The vein corresponding to this artery terminates in the long saphenous vein.

The **anterior cutaneous arteries** are derived from the deep and superior epigastric arteries. They emerge through the anterior wall of the sheath of the rectus abdominis in an irregular manner, and accompany more or less closely the anterior cutaneous nerves.

The veins corresponding to these arteries terminate in the deep and superior epigastric veins.

The **lateral cutaneous arteries** are branches of the lower five aortic intercostal and subcostal arteries, and they emerge with the lateral cutaneous nerves between the serrations of the external oblique muscle in the mid-axillary line.

The veins corresponding to these arteries are tributaries of the lower five intercostal and subcostal veins.

Superficial Lymphatics.—The superficial lymphatics *below* the level of the umbilicus accompany the superficial epigastric vessels, and terminate in the inguinal glands. Those *above* the level of the umbilicus pass to the axillary glands. The superficial lymphatics of the *lateral* abdominal wall terminate in two ways. Some accompany the superficial circumflex iliac vessels, and terminate in the inguinal glands; others accompany the abdominal branches of the lumbar arteries, and terminate in the deeply-placed lateral group

of lumbar glands. For the deep lymphatics of the antero-lateral abdominal wall, see p. 625.

Penis. Coverings.—The **skin** at the free extremity of the glans, being doubled upon itself, passes backwards until it reaches the constriction behind the corona glandis called the cervix. Here it is reflected forwards, closely investing the cervix, corona glandis, and body of the glans. On reaching the lips of the meatus urinarius it becomes continuous with the mucous membrane of the urethra. The skin covering the glans is provided with papillæ, but these do not appear on the surface. The duplicature, which the skin forms in the region of the glans, is called the *præputium penis*, or prepuce. The under part of the prepuce is connected to the under surface of the glans by a median, laterally compressed, triangular fold, called the *frenum præputii*, which extends as far as the lower part of the meatus urinarius. The skin of the cervix, corona glandis, and adjacent part of the inner surface of the prepuce contains large sebaceous glands, called the *glands of Tyson*. Their secretion is a whitish curdy substance, and is strongly odorous, from which character the glands have been called the *glandulæ odoriferæ*, the secretion being called the *smegma præputii* (unguent of the prepuce). The **dartos tunic** is situated immediately beneath the skin, and is destitute of adipose tissue. It is continuous with Camper's and Scarpa's fasciæ of the anterior abdominal wall, and with the tunica dartos of the scrotum, like which latter it contains involuntary muscular tissue. The **fascial investment** or **sheath** covers the penis, with the exception of the glans. It is situated beneath the dartos tunic, and at the cervix blends with the skin of the glans. Towards the root of the organ it receives expansions from the ischio-cavernosi and bulbo-cavernosi, and it covers the dorsal vessels and nerves. In this way the dorsal vein is compressed during the action of the ischio-cavernosi and bulbo-cavernosi. At the root of the organ the fascial investment blends with the two layers of the suspensory ligament.

Suspensory Ligament.—This ligament, which is strong and triangular, is composed of fibrous and elastic tissues. It is attached superiorly to the front of the symphysis pubis, where it is single, and inferiorly it divides into two laterally-disposed, diverging laminæ, which blend with the fascial sheath of the penis. The interval between the two laminæ is occupied by the dorsal vessels and nerves.

The **dorsal arteries.**—For the description of these arteries, see p. 588.

In addition to the dorsal arteries, the integument of the organ is supplied by the superior or superficial external pudic arteries, the branch from each of these vessels lying external to the dorsalis penis artery.

Dorsal Vein.—The tributaries which give rise to this vein come from the glans and prepuce. They form at first two dorsal veins, but these soon unite into one vessel, which passes backwards in the middle line, occupying the groove between the corpora

cavernosa, where it is under cover of the fascial sheath of the penis. At the root of the organ it passes between the two laminæ of the suspensory ligament, and then between the subpubic and transverse perineal or pelvic ligaments. In this part of its course it communicates with the venous plexus in the compressor urethræ muscle in which the internal pudic venæ comites arise. On entering the pelvis it divides into two branches, which terminate in the right and left portions of the prostatic plexus of veins.

For a description of the dorsal nerves of the penis, see p. 591.

The relation of the structures on the dorsum of the penis, from the middle line outwards, is as follows: dorsal vein, dorsal artery, and dorsal nerve.

Composition of the Penis.—The penis has two surfaces, upper or dorsal and under or scrotal. Viewed as a whole the organ is composed of three cylindrical bodies, namely, two corpora cavernosa and a corpus spongiosum, closely applied to each other. It is divisible into a root, body, cervix, and glans. The **root** is formed by the crura of the corpora cavernosa, which are attached to the inner margins of the ischio-pubic rami. The upper surface of the root is also connected to the symphysis pubis by the suspensory ligament. The upper or dorsal surface of the **body** is formed by the corpora cavernosa, the under or scrotal surface being formed by the corpus spongiosum in the middle line and the corpora cavernosa at either side. The corpora cavernosa and corpus spongiosum at their meeting become flattened, and so the shape of the body is subcylindrical. The corpora cavernosa terminate in round extremities, in front of which the corpus spongiosum turns upwards, and, becoming much enlarged, forms the glans penis. The **cervix** is the constriction between the body and the glans. The **glans penis** is formed by the corpus spongiosum. It is somewhat conical, and has been likened to an acorn, from which circumstance it has been called the *balanus*. At the base there is a wheel-like rim, called the *corona glandis*. The part anterior to the corona is called the body of the glans, and this terminates in a small round tip, which presents a vertical fissure called the *meatus urinarius*. For the structure of the penis, see p. 813.

Lymphatics.—These are divided into a superficial and deep set.

The **superficial lymphatics** of the prepuce, having formed a plexus, pass to the cervix, which they surround in the form of a ring. Those of the glans, having also formed a plexus, pass along with those of the spongy portion of the urethra to the foregoing ring. From this ring three lymphatic trunks proceed towards the symphysis pubis. One of these is median and dorsally placed, whilst the other two are disposed one on either side. The median trunk, when it reaches the suspensory ligament of the penis, divides into two branches, right and left. Each of these passes with the corresponding lateral trunk to the groin of the same side, where both terminate in the *pubic group* of the *inguinal glands*. The position of the foregoing three lymphatic trunks

accounts for the red lines which are often seen along the dorsum and sides of the penis when septic matter is absorbed from a venereal sore on the prepuce or glans. Their mode of termination also explains the occurrence of induration, or of suppuration, in the inguinal glands as the result of such sores, or of gonorrhœa.

The **deep lymphatics** return the lymph from the substance of the penis, and accompany the dorsalis penis vein into the pelvis, where they terminate in the *internal iliac glands*.

The lymphatics of the clitoris correspond with those of the penis.

Scrotum.—The wall of the scrotum is complex, and its constituent parts will be made more evident if they are enumerated in the order in which the testes receive them in their original descent from the abdominal cavity. It may be premised that the descent of each testis is preceded by a process of peritoneum, called the processus vaginalis, the lower part of which remains permanent as the tunica vaginalis scroti. The constituent parts of the scrotal wall, enumerated from within outwards, are as follows: tunica vaginalis scroti, subperitoneal areolar tissue, internal spermatic fascia, cremasteric or middle spermatic fascia, intercolumnar or external spermatic fascia, tunica dartos, and skin.

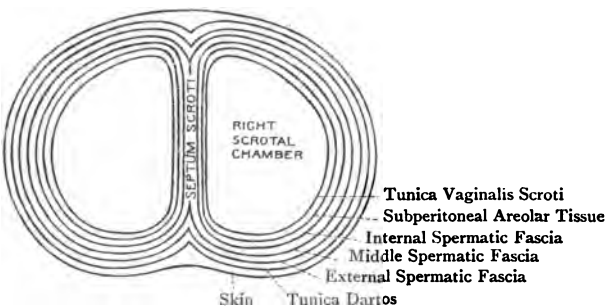

FIG. 274.—SCHEME OF THE STRUCTURES FORMING THE WALL OF THE SCROTUM (TRANSVERSE SECTION).

The **tunica vaginalis scroti** is the parietal layer of the tunica vaginalis.

The **subperitoneal areolar tissue** is composed of areolar and adipose tissues, and a certain amount of plain muscular tissue, its muscular element being known as the **middle cremaster.**

The **internal spermatic fascia** is derived from the fascia transversalis at the margins of the internal abdominal ring, in which vicinity it is called the **infundibuliform fascia.** In association with the subperitoneal areolar tissue it forms the *fascia propria* of Cooper.

The **cremasteric,** or **middle spermatic, fascia** is composed of striated muscular tissue, forming the cremaster muscle (external cremaster), and of areolar and elastic tissues. It is traceable superiorly to the lower border of the internal oblique and the centre of Poupart's ligament on its deep aspect.

The **intercolumnar,** or **external spermatic, fascia** is composed of connective tissue, and is derived from the intercolumnar fibres which extend between the columns of the external abdominal ring. The internal, middle, and external spermatic fasciæ are closely incorporated with one another.

The **tunica dartos** lies immediately within the skin. It is derived from the fasciæ of Camper and of Scarpa of the anterior abdominal wall. It is chiefly composed of plain muscular tissue, but it also contains fibro-areolar and elastic tissues, and it has a brick-red colour.

The **skin** is thin, very extensible, somewhat dark in colour, and provided with hairs, sweat-glands, and sebaceous glands. It is more dependent on the left side on account of the lower position of the left testis. In the middle line it presents a raphé, which is continuous behind with that of the anterior part of the perineum, and in front with that on the under surface of the penis. This raphé is an external indication of the bilateral symmetry of the scrotum. On either side of the raphé the skin is thrown into a number of transverse rugæ, the corrugated condition being due to the plain muscular tissue of the tunica dartos.

The interior of the scrotum is divided into two compartments, each of which lodges the corresponding testis. This division is effected by the **septum scroti**, formed by the fusion of the contiguous walls of the two scrotal chambers, except the skin, which forms one continuous investment to both. Inferiorly the septum is attached to the bottom of the scrotal chamber, and superiorly to the under surface of the root of the penis.

Blood-supply.—The scrotum receives its chief arterial supply from the superior and inferior external pudic branches of the common femoral of each side, and the superficial perineal branches of the internal pudic arteries.

The **veins** corresponding to these arteries terminate in the long saphenous and internal pudic veins.

The cremasteric branch of the deep epigastric of each side also takes part in the supply of the scrotal wall, the venous blood being returned into the deep epigastric vein, which at its termination is single.

Lymphatics.—The most of the lymphatics of the scrotum terminate in the *inner inguinal glands*, but those from the back part pass to the *internal iliac glands*.

Nerve-supply.—The nerves of the scrotum are as follows: (1) the external or posterior and internal or anterior superficial perineal branches of the pudic; (2) the long pudendal nerve of Sœmmering from the small sciatic; (3) the inguinal nerve (ilio-inguinal) from the lumbar plexus; and (4) twigs of the genital branch of the genito-crural nerve from the lumbar plexus. The two superficial perineal nerves and the long pudendal nerve are known as the **long scrotal nerves.**

Muscles of Abdominal Wall. Obliquus Externus Abdominis—*Origin.*—The outer surfaces of the lower eight ribs by means of eight fleshy slips, the upper five of which interdigitate with slips of the serratus magnus, and the lower three with slips of the latissimus dorsi.

Insertion.—(1) The anterior half of the outer lip of the iliac crest by fleshy fibres. (2) By means of an aponeurosis into (*a*) the linea alba; (*b*) the pubic spine and crest of the opposite side through means of the triangular fascia; (*c*) the front of the symphysis pubis; (*d*) the pubic spine of the same side; (*e*) the first inch

of the ilio-pectineal line; and (*f*) the anterior superior iliac spine.

Nerve-supply.—The lower five intercostal nerves and the subcostal nerve.

Action.—(1) The two muscles, acting conjointly, diminish the size of the abdominal cavity, and so compress the viscera, as in defæcation. (2) The two muscles, acting conjointly from their origins, raise the front part of the pelvis and flex it upon the thorax. (3) Acting conjointly from their insertions, they flex the thorax upon the pelvis, the vertebral column being also flexed in the lower thoracic and lumbar regions; but, if the column is fixed, the two muscles depress the lower eight ribs. (4) One muscle, acting from its origin, is a lateral flexor of the pelvis. When it acts from its insertion it flexes the thorax towards its own side and rotates it to the opposite side.

The most of the fibres of the external oblique pass downwards and forwards, coinciding in direction with those of the external intercostal muscles. The only parts of the muscle which are free are the part between the last rib and the iliac crest, and the part opposite the pubic crest. The aponeurosis attains its greatest width and strength at, and below, the level of the anterior superior iliac spine, and it is narrowest opposite the umbilicus. Superiorly it gives origin to fibres of the pectoralis major. Crossing the fibres of the aponeurosis in an upward and inward direction there are several superadded fibres. In the lower part of the abdominal wall these are specially well marked, and are here spoken of as the **intercolumnar fibres.** Under this name they spring from the outer third of Poupart's ligament, whence they pass upwards and inwards in a curved manner, the convexity being downwards. On arriving at the upper and outer part of the external abdominal ring they extend from one column to the other. They round off and close the ring, and are prolonged upon the spermatic cord to form the *intercolumnar* or *external spermatic fascia.*

The following parts of the external oblique aponeurosis require special description: Poupart's ligament, Gimbernat's ligament, the triangular fascia, the external abdominal ring, and the linea alba.

Poupart's ligament, also known as the **superficial crural arch,** is the thickened lower border of the external oblique aponeurosis, which is folded backwards. Externally it is attached to the anterior superior iliac spine, and internally to the pubic spine, from which it is reflected outwards and backwards upon the ilio-pectineal line for fully 1 inch to form Gimbernat's ligament. The ligament is curved, the convexity being directed downwards and outwards, which is due to the attachment of the iliac lamina of the fascia lata to its lower border. The convexity is greatest when the thigh is extended, abducted, and rotated outwards, in which position the fascia lata on the front of the thigh is tightened.

Relations—*Superficial.*—Skin; Camper's and Scarpa's fasciæ; superficial epigastric vessels, a little to the inner side of the centre; superficial circumflex iliac vessels just below its outer part; and the inguinal

glands along its lower border. *Deep.*—Internal oblique along the outer half, and transversalis abdominis along the outer third. Along the outer half the fascia transversalis and fascia iliaca are attached, and form a canal containing the deep circumflex iliac vessels. The fascia transversalis continues to be attached to the inner part, but loosely and only as far inwards as the base of Gimbernat's ligament. The deep crural arch is also a deep

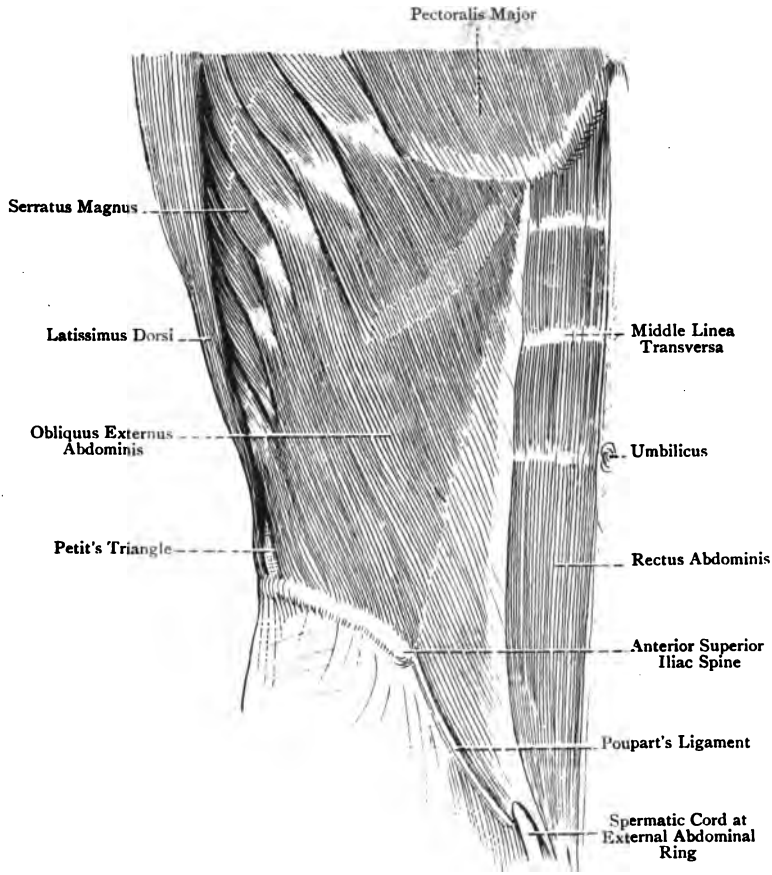

FIG. 275.—THE EXTERNAL OBLIQUE MUSCLE.

relation. Poupart's ligament, along with the irregularly concave border of the os innominatum, forms a large fibro-osseous canal. This region is known as the *lacunar region.*

The **deep crural arch** is a thickening of the fascia transversalis as it passes downwards beneath Poupart's ligament to form the anterior wall of the crural sheath. The thickening is due to superadded fibres which extend inwards from the centre of Poupart's ligament on its deep aspect to the ilio-pectineal line, where they are attached behind Gimbernat's ligament near its base.

Gimbernat's ligament is the reflection of Poupart's ligament from the pubic spine along the ilio-pectineal line. Its length is fully 1 inch, and it is triangular, the apex being at the pubic spine. It presents three borders and two surfaces. Two of the borders are fixed, one, called the *Poupart border*, being continuous with the inner end of Poupart's ligament, and the other, called the *pectineal border*, being implanted on the pectineal portion of the ilio-pectineal line. The third border is free, and is called the **base.** It is sharp, wiry, and concave, and is situated immediately to the inner side of the crural or femoral ring. The surfaces of the ligament are femoral and abdominal. They occupy an oblique plane, the *femoral surface* looking downwards, forwards, and slightly outwards, whilst the *abdominal surface* looks upwards, backwards, and slightly inwards. This latter surface, along its line of junction with Poupart's ligament, forms the floor of the inguinal canal in its lower third, where it supports the spermatic cord in the male, and the round ligament of the uterus in the female. The fascia transversalis takes attachment to the base of the ligament on its abdominal aspect, and the conjoined tendon and fascia transversalis are behind it at the ilio-pectineal line. A few of the fibres of the superior cornu of the saphenous opening terminate on the femoral surface of the ligament, and the pectineus muscle and pubic lamina of the fascia lata are in front of its pectineal attachment.

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The **triangular fascia**, also known as the *ligament of Colles*, is situated behind the spermatic cord and internal pillar of the external abdominal ring. Its fibres are derived from the external oblique aponeurosis of the opposite side, and, having crossed the linea alba, they take insertion into the pubic spine and crest. A portion of the fascia is seen lying in the lower and inner part of the external abdominal ring.

The **external abdominal ring** is an opening in the aponeurosis of the external oblique, and it is situated immediately above, and to the outer side of, the pubic spine. It serves for the passage of the spermatic cord in the male, and the round ligament of the uterus in the female. In the natural condition no opening is perceptible, the intercolumnar fibres rounding it off, and being prolonged downwards upon the transmitted structure. When the intercolumnar fibres and fascia have been removed, the ring is seen to be formed in the following manner: the fibres of the external oblique aponeurosis, as they approach the os pubis, are disposed in two diverging bundles. One bundle, which represents the inner end of Poupart's ligament, is fixed to the pubic spine. The other bundle passes to be attached to the front of the symphysis pubis, where its fibres decussate with those of its fellow of the opposite side, the fibres from the right side being superficially placed. An interval is thus left between these diverging bundles, which is widest at the lower and inner part, where it corresponds with a portion of the pubic crest. This interval is the external abdominal ring. Its direction is upwards and outwards, and

it is parallel with the inner part of Poupart's ligament. Its length is from 1 inch to 1½ inches, and its breadth at the base about ½ inch. It is triangular, the base being formed by part of the pubic crest, and the apex being directed upwards and outwards. The margins of the ring are called pillars or columns. From the oblique position of the ring one pillar is external and inferior, the other being internal and superior. The *internal* or *superior pillar*, which is thin and straight, passes to be attached to the front of the symphysis pubis. The *external* or *inferior pillar* is at first thin, but it soon becomes thick and prismatic, and is fixed to the pubic spine. It presents superiorly a concavity which lodges the spermatic cord in the male and the round ligament of the uterus in the female. The intercolumnar or external spermatic fascia is attached to both pillars, and it here lies upon the spermatic cord. Underneath the cord this fascia is attached along the pubic crest between the pillars of the ring. These attachments of the fascia explain why urine, extravasated into the perineum, does not find its way into the inguinal canal. Within the lower and inner part of the ring is the triangular fascia, and directly behind the ring is the conjoined tendon, which strengthens what would otherwise be a weak part of the abdominal wall. The ring is smaller in the female than in the male.

The **linea alba** has been already described (see p. 600).

The **triangle of Petit** is only present when the latissimus dorsi and external oblique do not meet. It is situated immediately above the centre of the iliac crest, and is bounded *in front* by the posterior border of the external oblique, *behind* by the anterior border of the latissimus dorsi, and *below* by the central portion of the iliac crest. It is covered only by skin and fascia, and its *floor* is formed by a part of the internal oblique. In this situation a lumbar hernia may occur, or a lumbar abscess may find its way to the surface.

Obliquus Internus Abdominis—*Origin.*—(1) The deep or abdominal surface of Poupart's ligament over its outer half; (2) the summit of the iliac crest over its anterior two-thirds; and (3) the *posterior* aponeurosis of the transversalis abdominis.

Insertion.—(1) The lower borders of the cartilages of the lower three or four ribs; (2) the lower borders of the cartilages of the seventh and eighth ribs, and the side of the ensiform process of the sternum; (3) the linea alba in its whole length; (4) the front of the pubic crest; and (5) the pectineal portion of the ilio-pectineal line for ½ inch.

Nerve-supply.—This is similar to that of the external oblique, with the addition of twigs from the inguinal nerve and hypogastric branch of the ilio-hypogastric, both of which are derived from the lumbar plexus, more particularly the first lumbar nerve.

Action.—This is similar to that of the external oblique. When the right internal oblique acts simultaneously with the left external oblique, the trunk is rotated to the right side, and *vice versâ*. To

understand this action, it is to be noted that the fibres of the internal oblique of one side coincide in direction with those of the external oblique of the opposite side.

The most of the fibres pass upwards and forwards across those of the external oblique, and coinciding with those of the internal intercostal muscles. The Poupart fibres, however, pass downwards and inwards, and join the corresponding fibres of the transversalis

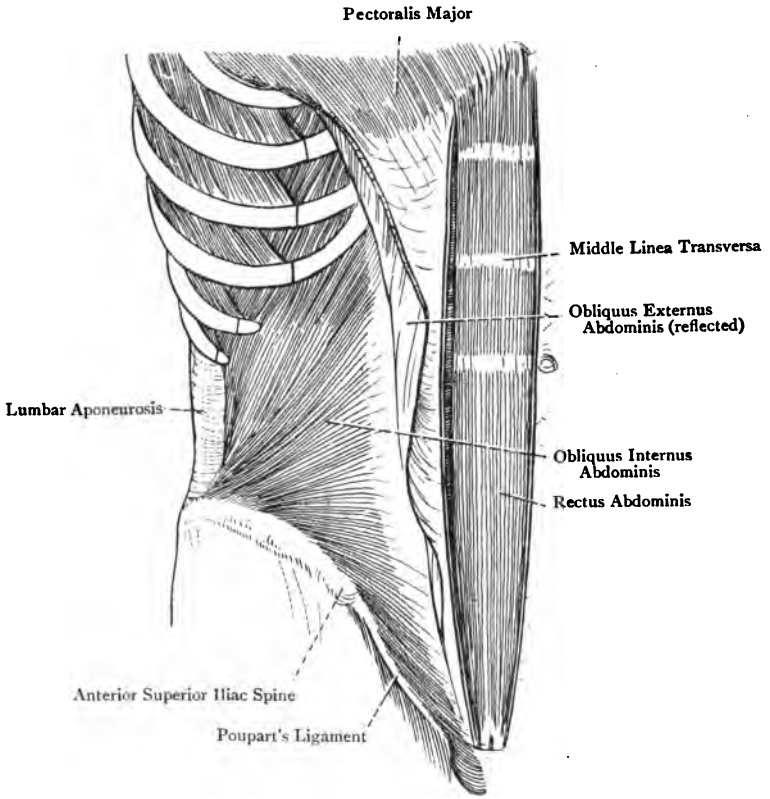


FIG. 276.—THE INTERNAL OBLIQUE MUSCLE.

abdominis to form the conjoined tendon. The aponeurosis is broader above than below. Along the outer border of the rectus abdominis, over about its upper three-fourths, it divides into two laminæ, one of which passes in front of the muscle and the other behind it. The anterior lamina joins the aponeurosis of the external oblique, and the posterior lamina joins the *anterior* aponeurosis of the transversalis abdominis. It is this latter lamina which has an insertion into the seventh and eighth costal cartilages and ensiform

process. Over about the lower fourth of the rectus the aponeurosis remains single, and passes in front of the muscle. The Poupart fibres of the muscle, as they leave the ligament, are in front of the spermatic cord as it lies in the upper third of the inguinal canal. They then arch over it, and finally descend behind it as it lies in the lower two-thirds of the inguinal canal. In this latter situation the fibres have terminated in the conjoined tendon.

Cremaster—*Origin.*—The deep aspect of Poupart's ligament in its inner part. A few fibres are also derived from the lower border of the internal oblique. The fibres descend in a series of loops upon the outer and anterior aspects of the spermatic cord. The lowest loops reach the tunica vaginalis of the testis, upon the upper part of which they spread out in an arched manner, some of the fibres terminating on it. The other loops are successively shorter from below upwards, and ascend on the inner and posterior aspects of the cord, where they become tendinous and indefinite, to take *insertion* into the pubic spine and anterior lip of the pubic crest. The loops of the muscle are separated by intervals occupied by areolar tissue. This combination of muscular loops and areolar tissue forms the *cremasteric* or *middle spermatic fascia*. The cremaster muscle lies in series with the lower border of the internal oblique, and is peculiar to the male. It is occasionally represented in the female by a few fibres which descend on the round ligament of the uterus in the inguinal canal.

Nerve-supply.—The genital branch of the genito-crural nerve from the lumbar plexus, more particularly from the first, and the ventral division of the second, lumbar nerves.

Action.—To support and raise the testis towards the external abdominal ring. The fibres composing the muscle are of the *striated* variety, but the action is involuntary, and of a reflex character.

Cremasteric Reflex.—The *afferent* nerve involved in the cremasteric reflex is either the **inguinal,** which is distributed to the side of the scrotum and inner side of the thigh, or the **crural branch** of the **genito-crural,** which is distributed to the integument over Scarpa's triangle. The *efferent* nerve is the **genital branch** of the **genito-crural.**

Transversalis Abdominis—*Origin.*—(1) The deep aspect of Poupart's ligament over its outer third; (2) the inner lip of the iliac crest over its anterior two-thirds; (3) the lumbar aponeurosis, which, by its *posterior* lamina, is connected with the spinous processes of the lumbar and sacral vertebræ, and the posterior fourth of the outer lip of the iliac crest, by its *middle* lamina with the tips of the lumbar transverse processes, and, by its *anterior* lamina, with the fronts of the lumbar transverse processes near their tips; and (4) the inner surfaces of the cartilages of the lower six ribs by six slips which interdigitate with slips of the diaphragm.

Insertion.—(1) The linea alba; (2) the front of the pubic crest; and (3) the pectineal portion of the ilio-pectineal line for 1 inch.

Nerve-supply.—This is similar to that of the internal oblique.

Action.—To diminish the capacity of the abdominal cavity, and so compress the viscera. To a limited extent the two muscles aid the external and internal oblique muscles in elevating the pelvis, flexing the thorax, and depressing the ribs.

The most of the fibres pass transversely forwards, and terminate in the anterior aponeurosis. The Poupart fibres, however, pass

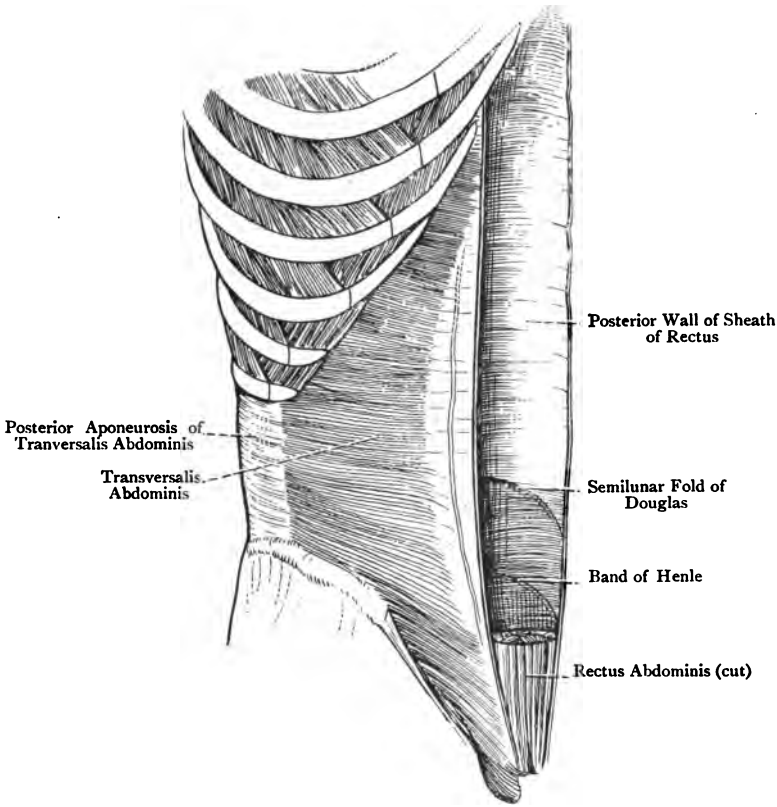


FIG. 277.—THE TRANSVERSALIS ABDOMINIS MUSCLE.

downwards and inwards, and join the corresponding fibres of the internal oblique to form the conjoined tendon. The *anterior aponeurosis* is narrow above, but broad below. Over about the upper three-fourths of the rectus abdominis it passes behind the muscle, but over about the lower fourth it passes in front of it. The transversalis abdominis is continuous superiorly with the triangularis sterni muscle, and its lower border is free where it arches over the spermatic cord, or the round ligament of the uterus.

For the *posterior aponeurosis* of the muscle, see p. 718.

Conjoined Tendon.—This is the tendon which gives a common insertion to the Poupart fibres of the internal oblique and transversalis abdominis muscles. It is *inserted* into (1) the front of the pubic crest, and (2) the pectineal portion of the ilio-pectineal line for 1 inch. The tendon is formed principally by the transversalis abdominis, which extends for 1 inch along the ilio-pectineal line, whilst the internal oblique only extends along that line for ½ inch.

Relations—*Superficial.*—The structures in front of the conjoined tendon, from the middle line outwards, are as follows: the lower part of the internal pillar of the external abdominal ring; the triangular fascia; the insertion of the cremaster; Gimbernat's ligament; the inner part of Poupart's ligament; and the spermatic cord. *Deep.*—The fascia transversalis.

The conjoined tendon varies greatly in development, and in many cases is hardly distinguishable. As a rule, it covers the inner two-thirds of the floor of Hesselbach's triangle, where it lies behind the inner two-thirds of the inguinal canal and has the spermatic cord, or the round ligament of the uterus, as a superficial relation. It also lies directly behind the external abdominal ring, and so strengthens what would otherwise be a weak part of the abdominal wall. In some cases the conjoined tendon is divisible into two parts, the outer being known as the *ligament of Hesselbach*, and the inner as the *ligament of Henle.*

Reflected Tendon of Cooper. — In normal circumstances the conjoined tendon is limited to the first inch of the pectineal portion of the ilio-pectineal line. Sometimes, however, the anterior aponeurosis of the transversalis abdominis is prolonged outwards beyond the normal limit of the conjoined tendon, in the form of a thin semilunar expansion which extends as far as the inner and lower parts of the internal abdominal ring, and is attached inferiorly to the deep crural arch. This semilunar expansion of the conjoined tendon is known as the **reflected tendon of Cooper.** Its concavity is directed outwards, and, when present, it covers the outer third of the floor of Hesselbach's triangle, where it lies behind the spermatic cord, and is closely connected with the subjacent fascia transversalis, to which it imparts strength.

An inspection of the external oblique, internal oblique, and transversalis abdominis muscles shows that they cross each other at different angles, the external oblique passing downwards and forwards, the internal oblique upwards and forwards (these two muscles thus crossing like the limbs of the letter X), and the transversalis horizontally forwards. They thus form an intricate lattice-work which renders the abdominal wall very strong, and is a powerful safeguard against hernial protrusions.

Rectus Abdominis—*Origin.*—This muscle arises by two heads, both of which are tendinous. The **external head**, broad and flat, arises from the pubic crest, and the **internal head**, narrow and somewhat round, from the fibrous structures in front of the symphysis pubis, where it is closely connected with its fellow of the opposite side. The two heads join about 1 inch above the symphysis pubis.

Insertion.—By means of three flat slips, which are at first fleshy and subsequently tendinous, into the anterior surfaces of the fifth, sixth, and seventh costal cartilages. The most internal slip is

sometimes partially inserted into the side of the ensiform process of the sternum.

Nerve-supply.—The lower five intercostal nerves and the subcostal nerve.

Action.—The action is similar to that of the two oblique and transversalis muscles, with the exception that it does not produce lateral rotation of the thorax.

The muscle is long, flat, and strap-like, its fibres being directed vertically upwards by the side of the linea alba. It is narrow below and broad above, its greatest breadth being about 3 inches. Below the umibilcus the two muscles are very near each other, the interval between them being not more than about $\frac{1}{8}$ inch. Above the umbilicus, however, the muscles are separated by an interval of about $\frac{1}{4}$ inch. Each muscle is marked by *tendinous intersections* or *inscriptions*, which cross it in a somewhat irregular manner at certain intervals. They are usually three in number, and are situated as follows : one at the level of the umbilicus, a second opposite the tip of the ensiform process, and a third about midway between these two. Sometimes there is a fourth inscription, which crosses the muscle a little below the umbilicus, but this one is faint, and does not usually extend the whole width. These inscriptions, which do not usually penetrate to the posterior surface, map out the upper part of the muscle into two quadrangular areas, and are firmly bound to the anterior wall of its sheath. Above the level of the umbilicus, therefore, the interior of the sheath, anterior to the muscle, is divided into two distinct compartments.

The tendinous inscriptions are the remains of the septa which separated the primitive myotomes or muscle-segments, and by some they are regarded as indicating the abdominal ribs of certain animals, such as the crocodile.

Pyramidalis Abdominis—*Origin.*—The front of the pubic crest.

Insertion.—The linea alba for 2 inches or more above the symphysis pubis.

Nerve-supply.—The subcostal nerve.

Action.—To render tense the linea alba.

The muscle is sometimes present only on one side ; sometimes it is absent on both sides ; and sometimes it is double on one or both sides. In man it is a small muscle, and vestigial like the plantaris ; but it attains a large size in marsupials, and especially in ornithorhynchus.

Sheath of Rectus Abdominis.—Over about the *upper three-fourths* of the muscle the **anterior wall** is formed by the anterior lamina of the internal oblique aponeurosis and the external oblique aponeurosis, the two being closely connected ; and the **posterior wall** is formed by the posterior lamina of the internal oblique aponeurosis and the anterior aponeurosis of the transversalis abdominis, these two being likewise closely connected. Over about the *lower fourth* the **anterior wall** is formed by the external oblique aponeurosis, the undivided internal oblique aponeurosis, and the

anterior aponeurosis of the transversalis abdominis, in this order from before backwards, all three being closely connected. Over this extent the sheath is deficient posteriorly, and the muscle rests upon the fascia transversalis, with an exception to be presently stated. The lower border of the posterior wall presents a free curved margin, with the concavity downwards, called the **semilunar fold of Douglas**, over which the deep epigastric artery passes. This fold is usually situated about the junction of the upper fourth and lower three-fourths of the infra-umbilical portion of the linea alba. Sometimes the anterior aponeurosis of the transversalis abdominis, though passing in front of the lower fourth of the rectus, sends scattered fibres behind it, which would thus intervene between the muscle and the fascia transversalis for a variable distance below the fold of Douglas. In such cases the posterior wall of the sheath presents another curved semilunar fold, situated from 1 to 2 inches below the semilunar fold of Douglas, and known as the **band of**

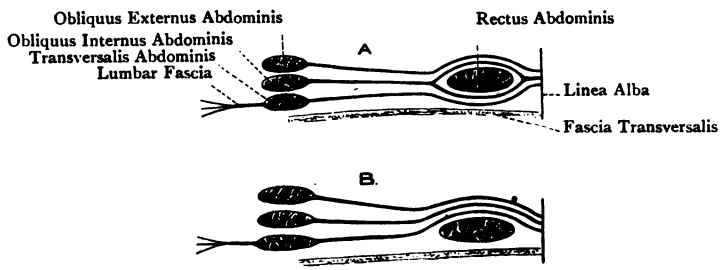


FIG. 278.—DIAGRAM SHOWING THE SHEATH OF THE RECTUS ABDOMINIS.
A, Over the upper three-fourths; B, over the lower fourth.

Henle, over which the deep epigastric artery passes. The **contents** of the sheath are as follows: the rectus abdominis, pyramidalis abdominis, deep epigastric vessels, superior epigastric vessels, and terminal parts of the lower five intercostal, and subcostal, nerves.

Relation of Structures at the Pubic Crest.—The relation of structures from before backwards is as follows:

1. The triangular fascia.
2. The conjoined tendon.
3. The pyramidalis.
4. The outer head of the rectus abdominis.
5. The fascia transversalis.

A few fibres of the cremaster are inserted into the pubic crest close to the pubic spine.

Relation of Structures at the Pectineal Portion of the Ilio-pectineal Line.—The relation of structures from before backwards is as follows:

1. The pubic lamina of the fascia lata, incorporated with which is the pubic ligament of Cooper.
2. The pectineus.
3. Gimbernat's ligament.
4. The conjoined tendon.
5. The fascia transversalis and the deep crural arch.

Deep Nerves of the Abdominal Wall.—The **lower five intercostal nerves,** after leaving the intercostal spaces, lie between the internal oblique and transversalis abdominis, and pass downwards and forwards to the outer border of the rectus. Here they pierce, in succession, the posterior wall of the sheath, the rectus, and the anterior wall of the sheath, after which they terminate in the anterior cutaneous nerves. In their course they supply the two oblique, the transversalis, and the rectus muscles. Each nerve gives off a lateral cutaneous branch in the mid-axillary line. These lateral cutaneous branches, having pierced the internal oblique, appear between the slips of the external oblique and divide into anterior and posterior branches.

The **subcostal nerve** is the anterior primary division of the twelfth thoracic nerve. It is in series with the eleventh intercostal, but is not ranked as an intercostal nerve, inasmuch as it lies along the lower border of the twelfth rib. It is commonly spoken of as the *last dorsal nerve.* Its abdominal relations, course, and distribution are similar to the preceding nerves, with an additional distribution to the pyramidalis abdominis. Its *lateral cutaneous* or *iliac branch,* which is undivided, having pierced the internal and external oblique muscles, descends over the anterior part of the iliac crest, 1 inch behind the anterior superior iliac spine, and is distributed to the integument of the anterior part of the gluteal region as low as the great trochanter of the femur.

The **ilio-hypogastric nerve,** having pierced the posterior part of the transversalis abdominis a little above the iliac crest, furnishes its *iliac branch* (lateral cutaneous), which perforates the internal and external oblique, and, having crossed the iliac crest at the junction of its middle and anterior thirds, is distributed to the integument of the adjacent part of the gluteal region. The nerve then continues its course forwards between the internal oblique and transversalis, supplying branches to these muscles and communicating with the inguinal nerve. About 1 inch in front of the anterior superior iliac spine it pierces the internal oblique, and runs forwards between the Poupart fibres of that muscle and the external oblique aponeurosis. Finally, it pierces that aponeurosis about 1 inch above the external abdominal ring, and is distributed to the integument of the suprapubic region, where it is in series with the anterior cutaneous nerves.

The **inguinal nerve** (ilio-inguinal), as it passes forwards, lies internal to the inner lip of the iliac crest, beneath the transversalis and upon the iliac fascia and iliacus muscle. Near the anterior part of the iliac crest it pierces the transversalis, and here communicates with the hypogastric branch of the ilio-hypogastric. It subsequently perforates the Poupart fibres of the internal oblique, after which it descends through the lower two-thirds of the inguinal canal, and emerges through the external abdominal ring where it lies external to the spermatic cord. Finally, it is distributed to the integument of the inner side of the thigh in its upper third,

and to the integument of the scrotum, or labium majus, according to the sex. The nerve in its course supplies branches to the internal oblique and transversalis muscles.

Deep Arteries of the Abdominal Wall.—The **deep epigastric artery** arises from the inner side of the external iliac, about ½ inch above Poupart's ligament. For a very short distance at first it passes inwards between Poupart's ligament and the lower border of the internal abdominal ring. It then changes its course, and passes upwards and inwards, lying close to the inner side of the internal abdominal ring, only the external vena comes intervening. On arriving at the outer border of the rectus abdominis, at a point about midway between the upper border of the symphysis pubis and the umbilicus, the artery passes beneath the muscle and enters the sheath over the semi-lunar fold of Douglas. It then changes its course, and ascends vertically between the muscle and the posterior wall of the sheath, as high as the umbilicus. Thereafter it enters the muscle, and, about 2 inches above the umbilicus, it ends in its terminal branches, which anastomose with branches of the superior epigastric artery. The deep epigastric lies at first in the subperitoneal areolar tissue, having the parietal peritoneum on its deep surface, and the fascia transversalis superficial to it. Shortly after passing the internal abdominal ring the vessel pierces the fascia transversalis, and in its course to the outer border of the rectus it forms the outer boundary of Hesselbach's triangle. As the vessel turns from the lower border to the inner side of the internal abdominal ring it has the spermatic cord in front of it, and the vas deferens here hooks round its outer side. The course of the vessel in its first or oblique part is indicated by a line drawn from the inner border of the internal abdominal ring to the outer border of the rectus abdominis at a point about midway between the umbilicus and the upper border of the symphysis pubis. The course of the second or vertical part of the vessel is represented by a vertical line corresponding with the centre of the rectus, and distant from the linea alba about 1½ inches.

Branches.—These are as follows: cremasteric, pubic, muscular, cutaneous, peritoneal, and terminal or anastomotic.

The *cremasteric artery* enters the spermatic cord and supplies the cremaster muscle and the other coverings of the cord. It anastomoses with the spermatic artery, the superior and inferior external pudic arteries, and the superficial perineal artery. The cremasteric artery is replaced in the female by the *artery of the round ligament of the uterus.*

The *pubic artery* passes inwards behind the inner half of Poupart's ligament to the back of the body of the os pubis, where it anastomoses with the pubic branch of the obturator artery and its fellow of the opposite side.

The *muscular branches* arise chiefly from the outer side of the deep epigastric, and supply the two oblique, transversalis, and

rectus muscles. They anastomose with the lower two intercostal arteries, the subcostal artery, the abdominal branches of the lumbar arteries, and the lateral or intermuscular epigastric (so called 'ascending branch') of the deep circumflex iliac artery.

The *cutaneous branches* perforate the rectus and the anterior wall of its sheath, to be distributed to the integument in which they anastomose with branches of the superficial epigastric.

The *peritoneal branches* pierce the posterior wall of the sheath of the rectus, to be distributed to the adjacent parietal peritoneum.

The *terminal* or *anastomotic branches* enter the rectus above the level of the umbilicus and anastomose with the superior epigastric of the internal mammary.

For an abnormal or aberrant obturator artery, see p. 436.

There are two venæ comites with the deep epigastric artery, one on either side. These ultimately join to form one vessel, which terminates in the external iliac vein.

The **superior epigastric artery** is one of the terminal branches of the internal mammary from the first part of the subclavian. It descends behind the seventh costal cartilage, passing between the sternal and costal portions of the diaphragm, and enters the sheath of the rectus, where it lies at first between the muscle and the posterior wall of its sheath. It then enters the muscle and anastomoses with the deep epigastric. Its branches are as follows: *metasternal*, which crosses in front of the metasternum and anastomoses with its fellow of the opposite side; *phrenic*, to the diaphragm; *muscular* to the muscles of the abdominal wall; *anterior cutaneous* to the integument; *falciform* or *hepatic* (present only on the right side), which passes to the liver in the falciform ligament and anastomoses with the hepatic artery; and *peritoneal*, which pierce the posterior wall of the sheath of the rectus, to be distributed to the adjacent parietal peritoneum. The vessel is accompanied by two venæ comites, which terminate in those of the internal mammary artery.

The **deep circumflex iliac artery** arises from the outer side of the external iliac nearly opposite the origin of the deep epigastric. It passes outwards and upwards behind the outer half of Poupart's ligament, where it is contained in a canal formed at the junction of the fascia transversalis and fascia iliaca. Having arrived at the anterior superior iliac spine, it pierces the fascia transversalis, and courses outwards and backwards along the iliac crest on its inner aspect. At its termination it anastomoses with the lumbar branch of the ilio-lumbar from the internal iliac. Over about the anterior half of the iliac crest the artery lies beneath the transversalis muscle, but about the centre of the crest it pierces that muscle, and subsequently lies between it and the internal oblique.

Branches. — In the first part of its course the vessel gives branches to the ilio-psoas, sartorius, and tensor fasciæ femoris, in which latter muscle it anastomoses with the ascending branch of the external circumflex from the arteria profunda femoris.

As it courses along the iliac crest it furnishes branches to the muscles of the abdominal wall, some of which reach the gluteal region, where they anastomose with the gluteal of the internal iliac and the superficial circumflex iliac of the common femoral. It also gives branches to the iliacus muscle, which anastomose with the iliac branch of the ilio-lumbar from the internal iliac. One of the muscular branches of the artery is very constant and of large size. It springs from the vessel near the anterior superior iliac spine, and, having pierced the fascia transversalis and transversalis muscle, it ascends vertically between that muscle and the internal oblique, where it anastomoses with the abdominal branches of the lumbar arteries. This branch is usually spoken of as *the ascending branch*, but it may be called the *lateral* or *intermuscular epigastric*.

The deep circumflex iliac artery is accompanied by two venæ comites. These ultimately join to form one vessel, which crosses the external iliac artery from without inwards about ½ inch above Poupart's ligament, and terminates in the external iliac vein.

The **lower two intercostal arteries** ultimately leave the tenth and eleventh intercostal spaces and pass towards the rectus muscle, lying in their course between the internal oblique and transversalis. They anastomose with the superior epigastric, deep epigastric, and subcostal arteries.

The **subcostal artery** lies below the last rib, and is in series with the aortic intercostal arteries above and the lumbar arteries below. On the abdominal wall it anastomoses with the last intercostal, the abdominal branch of the first lumbar, and the superior epigastric, arteries.

The **abdominal branches of the lumbar arteries** pass forwards towards the rectus abdominis. They anastomose with the deep epigastric, subcostal, and lateral or intermuscular epigastric of the deep circumflex iliac.

The veins corresponding to the lower two intercostal arteries terminate in the corresponding intercostal veins. The subcostal vein of the right side terminates in the right azygos vein, and that of the left side in the lower left azygos vein. The veins accompanying the abdominal branches of the lumbar arteries terminate in the lumbar veins, which are tributaries of the inferior vena cava.

Deep Lymphatics.—The deep lymphatics of the lower part of the *anterior* abdominal wall accompany the deep epigastric and deep circumflex iliac vessels, and terminate in the external iliac glands; those of the upper part accompany the superior epigastric artery, and terminate in the sternal glands.

The deep lymphatics of the lower part of the *lateral* abdominal wall accompany the abdominal branches of the lumbar arteries and the ilio-lumbar artery, and terminate in the lateral group of lumbar glands; those of the upper part accompany the adjacent anterior intercostal and musculo-phrenic arteries, and terminate in the sternal glands.

For the superficial lymphatics of the antero-lateral abdominal wall, see p. 607.

Fascia Transversalis.—The fascia transversalis is situated underneath the transversalis abdominis muscle. It is of greatest strength over the lower part of the abdominal wall, particularly between the lower free border of the transversalis and Poupart's ligament. When traced upwards to the costal margin it becomes very thin, and is there continuous with the fascia which covers the abdominal surface of the diaphragm. Along the linea alba it is continuous with the fascia of the opposite side. In the lumbar region it is continuous with the anterior wall of the sheath of the quadratus lumborum. In the region of the iliac crest it is attached to the anterior two-thirds of the crest immediately internal to its inner lip, where it meets and becomes continuous with the fascia iliaca, both of these fasciæ being here interposed between the transversalis and iliacus muscles. The most important disposition of the fascia is along the line of the groin, where its attachments are as follows: along the outer half of Poupart's ligament it is firmly attached to that ligament on its deep aspect, and over that extent it meets and is continuous with the fascia iliaca, the two fasciæ here forming a canal, which contains the deep circumflex iliac vessels. In the situation of the external iliac vessels, and as far inwards as the base of Gimbernat's ligament, it is only loosely attached to Poupart's ligament, and is here prolonged downwards beneath the ligament to the thigh, where it lies in front of the common femoral vessels, and forms the anterior wall of the crural sheath. As the fascia is prolonged beneath Poupart's ligament it is strengthened by superadded fibres, which are known as the *deep crural arch*. In the region of Gimbernat's ligament the fascia is attached in succession to the pectineal portion of the ilio-pectineal line behind the conjoined tendon, and to the pubic crest. Behind the symphysis pubis the fascia descends into the pelvis, and becomes continuous with the pubo-prostatic, or anterior true, ligaments of the bladder. The strongest part of the fascia transversalis, as before stated, is between the lower free border of the transversalis muscle and Poupart's ligament, this part of the abdominal wall being uncovered by muscular structures. It is in this situation where the fascia is pierced by the spermatic cord in the male and the round ligament of the uterus in the female.

Internal Abdominal Ring.—This ring is situated in the fascia transversalis at a point midway between the symphysis pubis and the anterior superior iliac spine, and ½ inch above Poupart's ligament. It serves for the passage of the spermatic cord in the male and the round ligament of the uterus in the female. As viewed from before no opening is visible in the undissected state, because the fascia transversalis is prolonged from the margins of the aperture round the spermatic cord as the infundibuliform or internal spermatic fascia. When fully dissected the ring is oval, with the long axis lying vertically, in which direction it measures ¾ inch,

the transverse measurement being ½ inch. The deep epigastric artery lies at first *below*, and then on the *inner* side of, the ring, the vessel being here beneath the fascia transversalis. The reflected tendon of Cooper may be upon the inner side of, and below, the ring. On the outer side of the ring are the Poupart fibres of the internal oblique, and above is the lower free border of the transversalis. The fascia at the outer and lower parts of the ring is stronger than elsewhere.

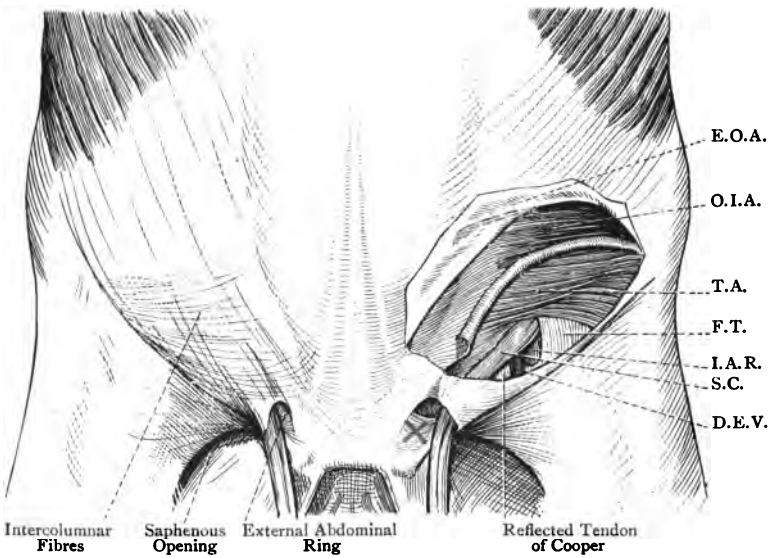


FIG. 279.—SUPERFICIAL AND DEEP DISSECTION OF THE LOWER PART OF THE ANTERIOR ABDOMINAL WALL (AFTER COOPER).

E.O.A. External Oblique Aponeurosis
O.I.A. Obliquus Internus Abdominis
T.A. Transversalis Abdominis
F.T. Fascia Transversalis
I.A.R. Internal Abdominal Ring
S.C. Spermatic Cord
D.E.V. Deep Epigastric Vessels
X. Triangular Fascia

Inguinal Canal.—The inguinal canal is the oblique passage in the lower part of the anterior abdominal wall, which transmits the spermatic cord, or round ligament of the uterus, according to the sex, and also the inguinal nerve in its lower two-thirds. It is situated immediately above the inner half of Poupart's ligament, its direction being downwards, forwards, and inwards, and it is 1½ inches in length. The inlet to the canal is the internal abdominal ring, the outlet being the external abdominal ring. Its component parts are a floor, a roof, an anterior wall, and a posterior wall. The **floor** in its upper two-thirds is formed by the meeting between the fascia transversalis and Poupart's ligament. This portion of it presents a groove, which lodges the spermatic cord. In the lower third the floor is formed by the

abdominal surface of Gimbernat's ligament along its line of junction with Poupart's ligament. The **roof** is formed by the apposition of the external and internal oblique muscles, and also by the lower borders of the internal oblique and transversalis. The **anterior wall** is formed by the following structures from before backwards: (1) the skin; (2) fascia of Camper; (3) fascia of Scarpa; (4) external oblique aponeurosis (all of these four structures extending over the whole length of the anterior wall); and (5) the Poupart portion of the internal oblique over the outer third. The **posterior wall** is formed by the following structures, in order from behind forwards: (1) the parietal peritoneum; (2) subperitoneal fat; (3) fascia

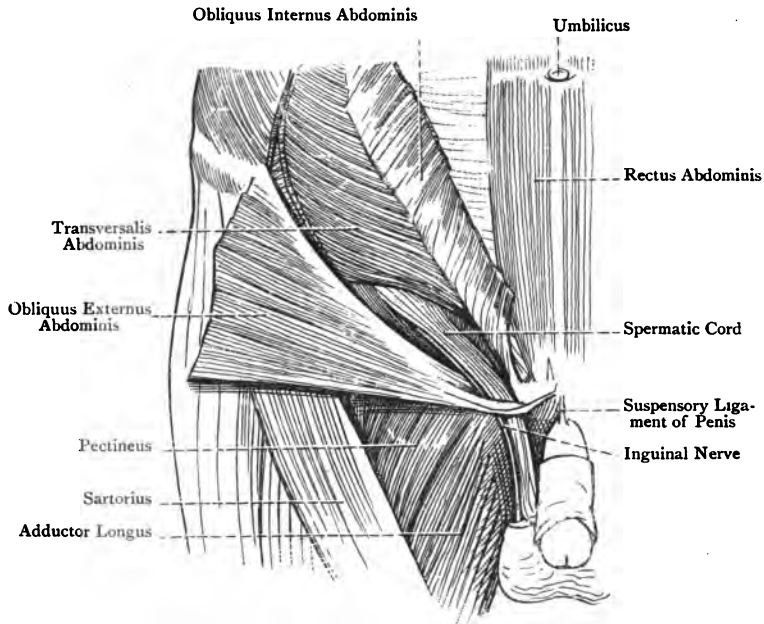


FIG. 280.—DISSECTION OF THE INGUINAL REGION.

transversalis; (4) conjoined tendon over the inner two-thirds, and it may be, the reflected tendon of Cooper over the outer third; and (5) the outer portion of the triangular fascia (provided that fascia is well developed), which lies over the extreme inner part of this wall.

In early life the inguinal canal is very short. Indeed, at one period of life it is non-existent, inasmuch as the internal abdominal ring in very early life lies directly behind the external ring. As the pelvis, however, increases in breadth, the internal ring is gradually shifted outwards, and so the inguinal canal becomes formed.

The inguinal canal in the female differs from that in the male in

being of smaller size, and in containing the round ligament of the uterus.

Triangle of Hesselbach.—This triangle is situated at the lower part of the anterior abdominal wall above the inner half of Poupart's ligament.

Boundaries—*Internal.*—The outer border of the rectus abdominis over about its lower 2 inches. *External.*—The deep epigastric vessels. *Inferior* (base).—The inner half of Poupart's ligament. The *apex* corresponds with the point where the deep epigastric vessels pass beneath the outer border of the rectus. The *floor* is covered over its whole extent by the fascia transversalis, superficial to which, over the inner two-thirds, is the conjoined tendon, and over the outer third, sometimes the reflected tendon of Cooper. The floor is, therefore, conveniently divided into an inner two-thirds, where the conjoined tendon lies, and an outer third, where the reflected tendon of Cooper may be situated. The triangle is covered superficially by the skin, the fasciæ of Camper and of Scarpa, and the external oblique aponeurosis.

Spermatic Cord.—The spermatic cord extends from the internal abdominal ring to the upper part of the posterior border of the testis. For the first 1½ inches of its course it lies in the inguinal canal, and is directed downwards, forwards, and inwards. After passing through the external abdominal ring it enters the scrotum, in which it descends almost vertically. The relations of the cord in the inguinal canal will be understood on referring to the description of that canal. In the lower two-thirds of the canal it is accompanied by the inguinal nerve.

The spermatic cord is composed of the following structures: the vas deferens or excretory duct of the testis; three arteries, namely, the spermatic artery, the artery of the vas deferens, and the cremasteric artery; the spermatic or pampiniform plexus of veins; the lymphatics of the testis and epididymis; the spermatic plexus of sympathetic nerves; and the genital branch of the genito-crural nerve. These structures are connected by areolar tissue, and the cord receives certain coverings to be presently described.

The **vas deferens** is the excretory duct of the testis. It commences at the lower end or globus minor of the epididymis, and terminates at the base of the prostate gland by joining the duct of the vesicula seminalis to form the common ejaculatory duct. This latter duct, having passed through the prostate gland for about 1 inch, opens upon (sometimes within) the margin of the opening of the sinus pocularis or prostatic vesicle on the floor of the prostatic portion of the urethra. The vas deferens at its commencement is slightly tortuous, but it soon becomes straight. It lies at first on the inner side of the epididymis, and along the posterior border of the testis. After entering the cord it is placed *behind* all the other elements, where it can be readily felt. It maintains this position until it arrives at the internal abdominal ring, where it lies on the *inner* side of the other elements of the cord.

After passing through the internal abdominal ring it hooks round the outer side of the deep epigastric artery, and, having crossed the external iliac vessels from without inwards, it dips down on the inner side of the external iliac vein, and so enters the pelvis under cover of the peritoneum, where it will be afterwards described. The vas deferens in its natural state measures about 1 foot in length, but when straightened it attains a length of from 1½ to 2 feet.

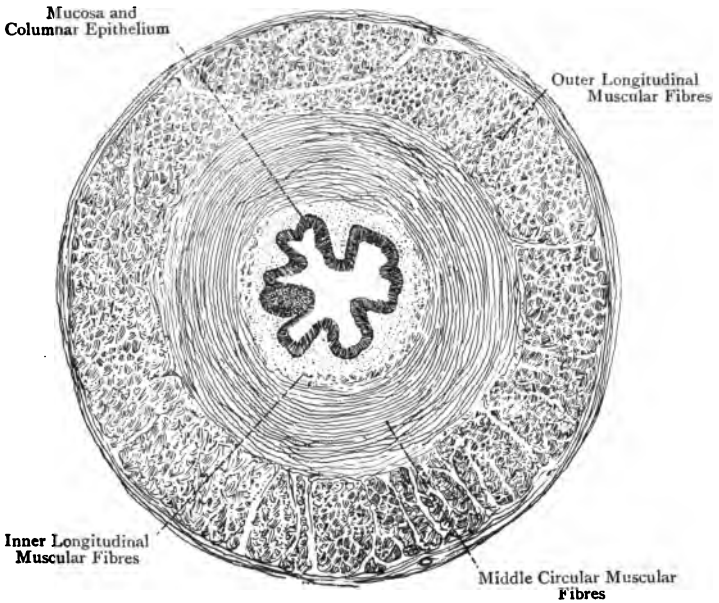


FIG. 281.—TRANSVERSE SECTION OF THE VAS DEFERENS, SHOWING ITS MINUTE STRUCTURE.

Structure of the Vas Deferens.—The vas deferens has a very thick wall, and feels like a piece of whip-cord. Its outer coat consists of fibrous tissue. Within this there is a thick muscular coat composed of plain muscular tissue, which is arranged in three layers—an outer longitudinal, a middle circular (both of which are thick), and an inner thin longitudinal layer. Within the muscular coat is the mucosa, which is covered by non-ciliated columnar epithelium. The lumen of the tube has a diameter of about $\frac{1}{30}$ inch.

The **artery of the vas deferens,** or **deferential artery,** is usually a branch of the superior vesical of the internal iliac, though it may arise from the inferior vesical, and it divides into a descending and an ascending branch. The *descending branch* passes downwards to supply the lower part of the vas deferens and the vesicula seminalis. The *ascending branch* accompanies the vas deferens through the inguinal canal to the testis, supplying the vas deferens, and giving a few twigs to the globus minor of the epididymis, in which latter situation it anastomoses with the epididymal branch

of the spermatic artery. The deferential artery is sometimes of large size, and then it takes the place of the spermatic artery when that vessel is absent.

The **deferential vein** opens into the vesical plexus of veins, and thence into the internal iliac vein.

The **spermatic artery** arises from the abdominal aorta about 1 inch below the renal artery. On approaching the upper part of the testis it divides into *testicular* and *epididymal branches*, the former supplying the testis and the latter the epididymis. As

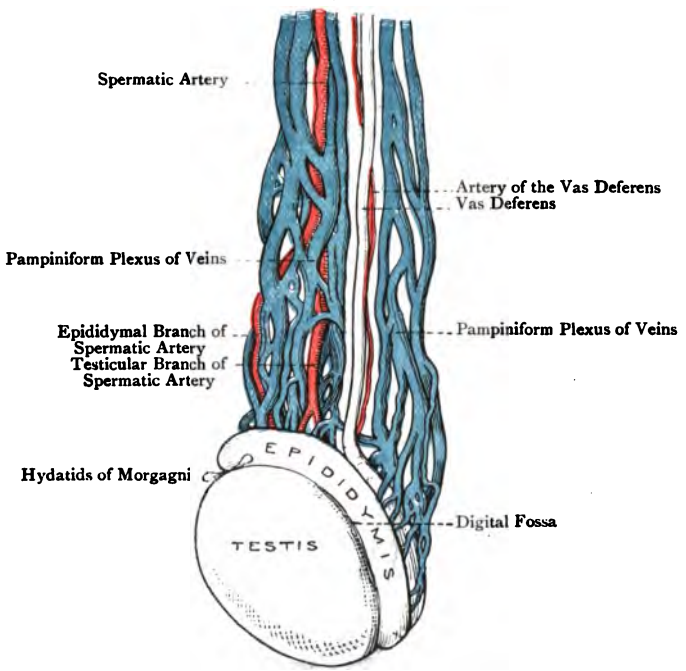


FIG. 282.—DISSECTION OF THE SPERMATIC CORD, SHOWING THE BLOOD-VESSELS AND DUCT OF THE TESTIS (AFTER SAPPEY).

the artery descends in the spermatic cord it supplies branches to its coverings which anastomose with the cremasteric artery, and its epididymal branches anastomose with the deferential artery.

For the **cremasteric artery,** see p. 623.

The **spermatic veins** issue from the testis along its posterior border. In the cord they form a copious plexus, called the **pampiniform plexus.** At the internal abdominal ring two veins emerge from this plexus, which range themselves on either side of the spermatic artery. These, as they ascend, soon join to form one vessel, that of the *right* side opening into the inferior vena cava, and that of the *left* side into the left renal vein. The veins of

the spermatic plexus have valves, but they are not competent. There is, however, a competent valve as a rule at the termination of each spermatic vein.

The lymphatics of the testis and spermatic cord, the spermatic plexus of sympathetic nerves, and the genital branch of the genito-crural nerve will be afterwards described.

Coverings of the Spermatic Cord.—The coverings, enumerated from within outwards, are as follows :

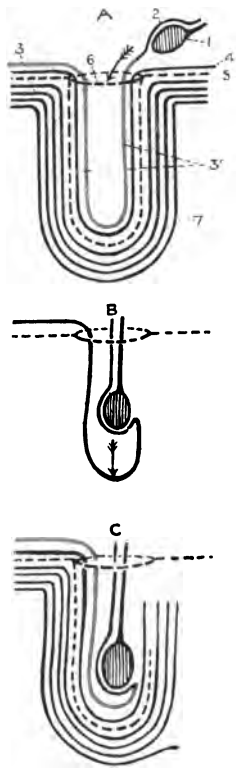
1. The subperitoneal areolar tissue, which is continuous with that of the abdominal wall through the internal abdominal ring. It contains a certain amount of muscular tissue, which is known as the *middle cremaster*.
2. The fascia transversalis, prolonged from the margins of the internal abdominal ring, and known as the *internal spermatic fascia*. This covering near the ring is funnel-shaped, and is thence called the *infundibuliform fascia*, but lower down it becomes incorporated with the subperitoneal areolar tissue, and forms the *fascia propria* of Cooper.
3. The cremasteric fascia, or *middle spermatic fascia*.
4. The intercolumnar fascia, or *external spermatic fascia*.
5. The tunica dartos.
6. The skin.

Within the innermost of these coverings there are a few scattered muscular fibres, which constitute the *internal cremaster of Henle*, and which are regarded as representing the inverted lateral bands of the gubernaculum testis.

It is to be noted that the *middle cremaster* is the muscular tissue contained in the subperitoneal areolar tissue on the surface of the cord, whilst the *external cremaster* is the more distinct muscular structure which is derived from the lower border of the internal oblique. The fibres of the external cremaster are of the striated variety, but those of the middle and internal are of the plain variety.

Descent of the Testis.—The testis is originally situated in the abdominal cavity upon the psoas magnus muscle, below and behind the kidney. It is almost completely invested by the peritoneum, which forms a fold behind it, called the **mesorchium.** This is to be regarded as a peritoneal ligament attaching the testis to the posterior abdominal wall, and so holding it in position. At this period there is present a band of plain muscular fibres, called the **gubernaculum testis.** The gubernaculum is attached superiorly to the lower part of the testis, and also to the peritoneum lining the adjacent portion of the posterior abdominal wall. Inferiorly, in the inguinal region, it is disposed in three divisions—external, internal, and middle. The external division is attached to the abdominal wall close to the internal abdominal ring, the internal to the pubic crest, and the middle to the integument of the groin which subsequently forms the scrotum. The descent of the testis commences about the third or fourth month of intra-uterine life, and, as it descends, it carries its *primitive peritoneum* along with it. It arrives at the internal abdominal ring about the sixth month, where it remains stationary until about the seventh month. At this latter period it commences its descent through the inguinal canal, and, by the eighth month it has usually reached the scrotum, the left testis arriving there a little earlier than the right.

Preparatory to the descent of the testis through the inguinal canal a diverticulum of the parietal peritoneum, called the **processus vaginalis,** passes through the inguinal canal into the scrotum. This process carries before it coverings from the fascia transversalis, from the lower border of the internal oblique muscle (cremaster muscle), and from the pillars of the external abdominal ring (intercolumnar or external spermatic fascia). The testis, covered by its primitive peritoneum, enters the pouch formed by the pro-



283.—DIAGRAM SHOWING THE DESCENT OF THE TESTIS.

A, First Stage; B, Second Stage; C, Final Stage.

1. Testis (in Abdomen)
2. Primitive Peritoneum (Tunica Adnata)
3. Parietal Peritoneum
3'. Processus Vaginalis
4. Subperitoneal Areolar Tissue
5. Fascia Transversalis
6. Internal Abdominal Ring
7. Integument

cessus vaginalis, and so descends through the inguinal canal into the scrotum, accurately following the lead of the middle division of the gubernaculum testis. During the descent of the testis from its original position to the internal abdominal ring all three divisions of the gubernaculum testis are being shortened. When the organ has arrived at the internal ring the external and internal divisions are practically horizontal, and, during its further descent into the scrotum, these two divisions are elongated in an

inverse or downward direction, their fasciculi becoming very scattered, and representing the so-called internal cremaster muscle. When the testis has reached the scrotum the middle gubernacular division has necessarily become extremely short, and it is ultimately represented by a little fibrous tissue which attaches the lower part of the testis to the bottom of the scrotal chamber.

Certain changes take place in the processus vaginalis after the testis has reached the scrotum. In the first place, the upper opening of the processus vaginalis becomes closed just before birth, and then the interior of the process represents an elongated shut sac. In the second place, a few days after birth, the process becomes constricted and closed just above the testis. The part above this latter closure, and as high as the internal abdominal ring, becomes impervious, and usually disappears in the first month after birth; but the part below it remains persistent, and forms the *parietal portion* of the tunica vaginalis. The *visceral portion* of the tunica vaginalis is formed by the primitive peritoneum which originally covered the testis whilst in the abdomen, and which the organ carries along with it in its descent; hence the visceral portion is sometimes called the **tunica adnata** ('born to'). In normal cases all that is left in the adult of the original processus vaginalis is (1) the lower part, which forms the parietal portion of the tunica vaginalis (tunica

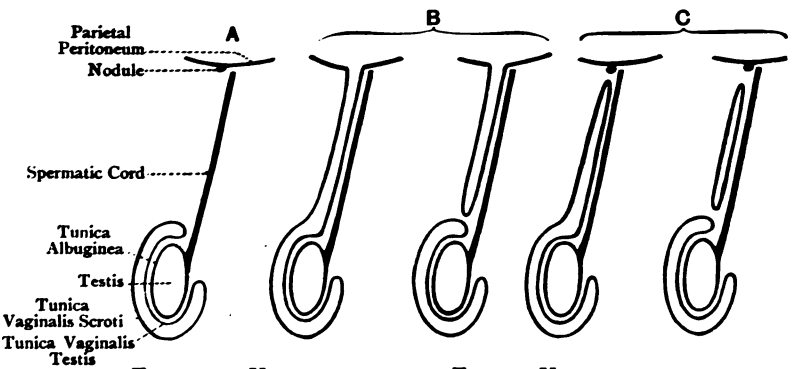


FIG. 284.—VARIETIES OF THE TUNICA VAGINALIS.

A, Normal Type; B, Congenital Type; C, Infantile Type.

vaginalis scroti), and (2) a small nodule upon the parietal peritoneum immediately behind the internal abdominal ring. Instead of a mere nodule, however, a delicate fibrous thread, known as the **ligamentum vaginale**, may extend from this part of the peritoneum downwards upon the front of the spermatic cord as far as the external abdominal ring, and in some cases as low as the tunica vaginalis.

Two views are held as to the descent of the testis. One view is that the descent of the organ is brought about by the contraction of the gubernacular fibres, and according to this view the external and internal gubernacular divisions would draw the testis down to the internal and external abdominal rings respectively, whilst the middle gubernacular division would steer or guide it into the scrotum. The other view is that the descent is brought about by developmental changes which are gradually taking place at this period in the surrounding parts.

Abnormal Conditions of the Processus Vaginalis—Congenital Type.—(1) The processus vaginalis may remain permanently open throughout, under which circumstances the cavity of the tunica vaginalis is in direct communication with the general peritoneal cavity. (2) The processus vaginalis may be closed just above the tunica vaginalis, but it may remain as a permanently open tube above this point.

Infantile or Funicular Type.—(1) The processus vaginalis may be closed only at its upper end near the internal abdominal ring. In these cases the tunica vaginalis, instead of being limited to the region of the testis, is prolonged upwards as an elongated tube in front of the spermatic cord into the inguinal canal. (2) The processus vaginalis may be closed above, near the internal abdominal ring, and also below, just above the tunica vaginalis, the portion of it intervening between these two points remaining as an elongated tube, closed at either end, and lying in front of the spermatic cord.

The funicular portion of the processus vaginalis is sometimes closed at intervals along the course of the spermatic cord, and, when serous fluid accumulates in the intervening patent portions, the condition is known as encysted hydrocele of the cord.

For the structure and development of the testis, see pp. 642, 644.

Subperitoneal Fat or **Areolar Tissue.**—This is situated between the fascia transversalis and the parietal peritoneum. Its condition is subject to much variety, being fairly well marked in some bodies, and in others hardly perceptible. Internal to the external iliac vein at Poupart's ligament it forms the *septum crurale*, which closes the upper end of the crural canal, and at the internal abdominal ring it is carried downwards round the spermatic cord underneath the infundibuliform fascia.

Parietal Peritoneum.—This is the innermost covering of the abdominal wall, and it is connected with the fascia transversalis by the subperitoneal areolar tissue. Behind the internal abdominal ring it forms a slight projection, which in some cases enters the ring, the corresponding depression on its abdominal aspect at this point being known as the **digital fossa.** The projecting part of the parietal peritoneum corresponds with the upper end of the original processus vaginalis, and presents a slight nodule, or it may be a slender thread-like process. It is here in the female where a diverticular process may extend for a short distance into the inguinal canal in front of the round ligament of the uterus, forming the canal of Nuck.

Peritoneal Plicæ and Inguinal Fossæ.—The peritoneum lining the posterior surface of the anterior abdominal wall below the umbilicus presents plicæ or folds and fossæ or pouches.

The **plicæ** are five in number, one being situated in the middle line, and two on either side. The median plica extends from the apex of the bladder to the umbilicus, and contains the urachus. It is called the **plica urachi.** Of the two lateral plicæ the more internal one contains the obliterated hypogastric artery, and is called the **plica hypogastrica.** It is oblique in direction, and meets the plica urachi and its fellow of the opposite side at the umbilicus. It corresponds to the junction of the inner two-thirds and outer third of Hesselbach's triangle. The external of the two lateral plicæ is produced by the deep epigastric artery, and is called the **plica epigastrica.**

The **inguinal fossæ** are six in number, three right and three left, and are called internal, middle, and external. The **internal inguinal fossa** is situated between the plica urachi and plica hypogastrica, and lies behind the inner two-thirds of Hesselbach's

triangle, the conjoined tendon, and the external abdominal ring. The **middle inguinal fossa** is situated between the plica hypogastrica and plica epigastrica, and lies behind the outer third

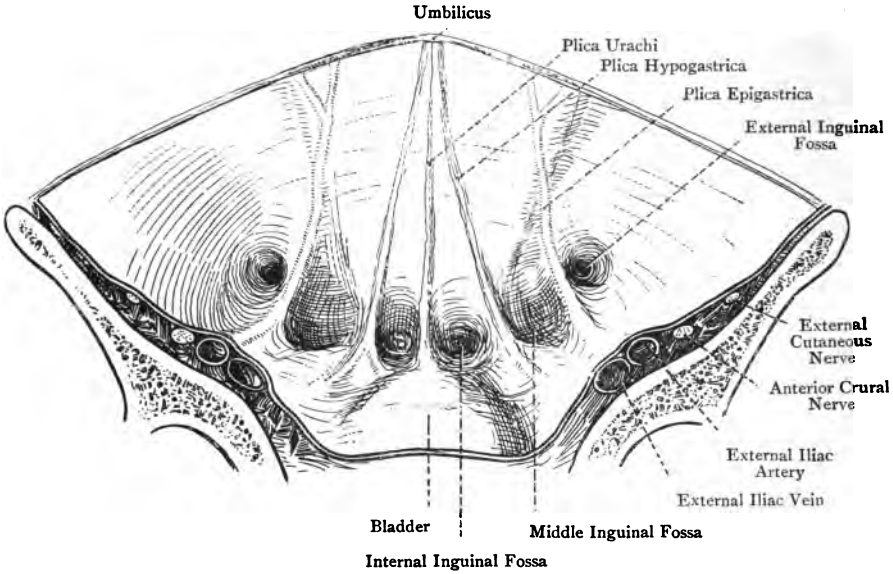


FIG. 285.—THE PLICÆ AND FOSSÆ ON THE POSTERIOR SURFACE OF THE ANTERIOR ABDOMINAL WALL.

of Hesselbach's triangle. The **external inguinal fossa** is situated on the outer side of the plica epigastrica, and its lower and inner part is behind the internal abdominal ring.

INGUINAL HERNIA.

By an inguinal hernia is meant a protrusion of a viscus (usually bowel, or, it may be, great omentum) from the abdominal cavity in the inguinal region. This region is predisposed to such an occurrence from the presence of the two abdominal rings and inguinal canal, and the inguinal fossæ. All forms of inguinal hernia, if complete, ultimately protrude through the external abdominal ring, and thereafter enter the scrotum. Relatively to the deep epigastric artery there are two varieties of inguinal hernia, namely, external and internal, the former leaving the abdominal cavity external to that vessel, and the latter escaping internal to it. Inasmuch, however, as the region inside the deep epigastric artery, namely, Hesselbach's triangle, is divisible into an inner two-thirds and an outer third, there may be two forms of internal hernia. Viewing, therefore, inguinal hernia in its relation to the abdominal wall, there are three varieties, namely, external oblique, internal direct, and internal oblique.

External Oblique Inguinal Hernia.—This variety is called *external* because the hernia, as it leaves the abdominal cavity, is external to the deep epigastric artery, and *oblique*, from its oblique course. The course of the hernia is as follows: it enters the external inguinal fossa, and elongates

before it the peritoneum forming that fossa. It then passes through the internal abdominal ring, and traverses the entire length of the inguinal canal, from which it emerges through the external abdominal ring into the scrotum, thus forming a complete external oblique inguinal hernia. Throughout its entire course the hernia lies in front of the spermatic cord, and its descent is arrested at the upper part of the testis, which can be felt at its lower and back part. The bowel may be arrested at any part of the inguinal canal, the hernia being then called incomplete, and forming what is known as a *bubonocele*. In its descent the bowel elongates and carries before it certain investments from the structures to which it is related, these investments being called the **coverings** of the hernia. The first covering of this form of hernia, as of the other varieties, is derived from the parietal peritoneum, the particular part being that which forms the external inguinal fossa, and this constitutes the **sac.** The other coverings are simply those of the spermatic cord, which are all superadded to the sac.

The **coverings,** enumerated in order from within outwards, are as follows:

1. Parietal peritoneum, which forms the sac.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis, from the margins of the internal abdominal ring, forming the infundibuliform or internal spermatic fascia.
4. Cremasteric or middle spermatic fascia, at the lower border of the internal oblique muscle.
5. Intercolumnar or external spermatic fascia, from the pillars of the external abdominal ring.
6. Tunica dartos.
7. Skin.

A short distance below the internal abdominal ring the subperitoneal fat and infundibuliform fascia become united, and are known as the **fascia propria.**

The **sac** is composed of the following parts: (1) the *mouth*, which is the opening by which its interior communicates with the general peritoneal cavity; (2) the *neck*, which is the constricted part immediately beyond the mouth; and (3) the *body*. The neck of the sac is on a level with the margins of the internal abdominal ring, and the deep epigastric vessels lie immediately on its *inner* side.

The seat of stricture may be (1) at the external abdominal ring; (2) at the lower border of the internal oblique muscle; or (3) at the neck of the sac, the last being the most common situation.

Internal Direct Inguinal Hernia.—This variety is called *internal* because the hernia, as it leaves the abdominal cavity, is internal to the deep epigastric artery, and *direct*, from its straight course through the abdominal parieties. The course of this variety is as follows: the hernia enters the internal inguinal fossa, elongating before it the peritoneum forming that fossa. It then passes through the inner two-thirds of Hesselbach's triangle, and so reaches directly the external abdominal ring without traversing the inguinal canal. Having emerged through the external ring it descends into the scrotum, thus forming a complete internal direct inguinal hernia, which is in front of, and internal to, the spermatic cord. It is to be noted (1) that there is no natural opening in the fascia transversalis over the inner two-thirds of Hesselbach's triangle, as there is external to the deep epigastric artery, and (2) that the conjoined tendon covers the inner two-thirds of Hesselbach's triangle. The coverings of this variety, enumerated in order from within outwards, are as follows:

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. Conjoined tendon.
5. Intercolumnar or external spermatic fascia.
6. Tunica dartos.
7. Skin.

If the hernia occurs suddenly, rupture of the conjoined tendon may take place, in which cases the bowel would pass through the fissure. The seat of

stricture in an internal direct inguinal hernia may be (1) at the external abdominal ring, (2) at the fissure in the conjoined tendon, if that structure should be ruptured, or (3) at the neck of the sac. The latter situation is the most common, and it is to be noted that the deep epigastric vessels lie on the *outer* side of the neck of the sac.

Internal Oblique Inguinal Hernia.—This variety is called *internal* because the hernia, as it leaves the abdominal cavity, is internal to the deep epigastric artery, and *oblique*, because it has to descend through the lower two-thirds of the inguinal canal. The course of this variety is as follows: the hernia enters the middle inguinal fossa, elongating before it the peritoneum forming that fossa. It then passes through the outer third of Hesselbach's triangle and descends through the lower two-thirds of the inguinal canal, from which it emerges through the external abdominal ring into the scrotum, thus forming a complete internal oblique inguinal hernia. Practically the only difference between the course of an internal oblique and an external oblique inguinal hernia is that the external oblique variety enters the inguinal canal by its natural inlet, namely, the internal abdominal ring, whereas the internal oblique variety obtrudes itself into the upper part of the inguinal canal through its posterior wall. It is to be noted (1) that there is no natural opening in the fascia transversalis over the outer third of Hesselbach's triangle, as there is external to the deep epigastric artery, and (2) that there is no conjoined tendon over the outer third of Hesselbach's triangle. The coverings of this variety, enumerated in order from within outwards, are as follows:

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. Cremasteric or middle spermatic fascia.
5. Intercolumnar or external spermatic fascia.
6. Tunica dartos.
7. Skin.

If the coverings of an external oblique, and an internal oblique, inguinal hernia are compared with each other, it will be seen that the former has a tube of fascia transversalis already prepared for it, namely, the infundibuliform fascia, whereas the latter has to elongate before it a fresh portion of fascia transversalis. In some cases the fascia transversalis over the outer third of Hesselbach's triangle is covered by an expansion from the conjoined tendon, which is known as the reflected tendon of Cooper. In such cases that reflected tendon must be added as a covering of internal oblique inguinal hernia, its position being immediately superficial to the covering formed by the fascia transversalis. The relation of an internal oblique inguinal hernia to the spermatic cord is similar to that of an external oblique, and the possible seats of stricture are also similar. The neck of the sac is the most common situation, and the deep epigastric vessels lie immediately on its *outer* side. The extreme difficulty which must be experienced in diagnosing between an external oblique and an internal oblique hernia is explained by the fact that the former leaves the abdominal cavity immediately external to the deep epigastric vessels, and the latter immediately internal to them. Hence, the practical rule followed in operating is to cut upwards and not transversely. The propriety of this rule is further enhanced if it be remembered that an external oblique inguinal hernia of old standing may so drag upon the internal abdominal ring as to displace it downwards and inwards to a point behind the external ring, and thus a hernia which is really external oblique may simulate one of the internal direct variety.

Varieties of External Oblique Inguinal Hernia.—There are two varieties of this form of hernia, the special features of which depend upon abnormal conditions of the processus vaginalis (see p. 634). These varieties are named congenital and infantile.

Congenital Hernia.—There are two forms of congenital hernia. (1) The processus vaginalis may remain permanently open throughout, in which case the bowel descends within that process into the cavity of the tunica vaginalis at its lower extremity. The tunica vaginalis thus represents the

sac of the hernia, and this form is therefore spoken of as a **hernia into the tunica vaginalis.** In such cases the bowel more or less completely envelops the testis. (2) The processus vaginalis may be shut off only just above the testis, the part above this remaining as a funicular process communicating above with the general peritoneal cavity. In such cases the bowel descends into the funicular process, which thus forms the sac of the hernia. This form is therefore spoken of as a **hernia into the funicular process.**

Infantile Hernia.—There are two forms of infantile hernia, **infantile hernia proper** and **encysted hernia.** In both there is a funicular process which is closed *above,* towards the internal abdominal ring. It may also be closed below just above the testis, being thus distinct from the tunica vaginalis, or it may simply be an upward extension of the tunica vaginalis. In either case it is situated in front of the spermatic cord. In **infantile hernia proper** the bowel, having elongated the parietal peritoneum to form a sac, descends between the spermatic cord and the funicular process. Its importance consists in the fact that, before the bowel can be exposed in operating, *three serous layers* must be divided, two of these belonging to the funicular process and the other representing the wall of the hernial sac. In this form the descent of the bowel is arrested at the upper part of the testis. In **encysted hernia** the bowel, having elongated the parietal peritoneum to form a sac, pushes against the upper part of the funicular process so as to invaginate it in a downward direction in the form of a cup, in which the bowel, enclosed in its sac, lies. The condition of matters is therefore very much like an egg set in its cup, assuming that the top of the shell is removed, and that the wall of the cup is formed of two layers. To bring out this simile, the contents of the egg may be taken as representing the bowel, the shell of the egg being the sac of the hernia, and the assumed two layers of the wall of the cup representing the two serous layers of the doubled down or invaginated funicular process, the cavity thus formed representing the inside of the cup. In this form, as in infantile hernia proper, *three serous layers* must be divided before the bowel is exposed in operating, two of these belonging to the invaginated funicular process and the other representing the wall of the hernial sac.

Umbilical Hernia (Exomphalos).—By an umbilical hernia is meant a protrusion of bowel or of great omentum from the abdominal cavity through the umbilicus. The protrusion occurs through the *upper* part of the umbilicus, which, containing only the obliterated umbilical vein, is weaker than the lower part where the obliterated hypogastric arteries and the urachus lie. The coverings of an umbilical hernia are as follows :

1. Parietal peritoneum.
2. Subperitoneal fat or areolar tissue.
3. Fascia transversalis.
4. An expansion from the decussating fibres of the aponeuroses of the abdominal muscles of opposite sides.
5. Superficial fascia.
6. The cicatricial cutaneous umbilical tissue.

There is no vessel liable to be injured in operating on this form of hernia, the deep epigastric artery being about 1½ inches from the linea alba.

The **congenital form** of umbilical hernia consists in a protrusion of bowel or omentum through the centre of the umbilicus into the umbilical cord, in which it may descend for some distance. Its possible presence will show the propriety of carefully examining the cord before ligaturing it after birth.

The anterior abdominal wall above the level of the umbilicus presents a median fold of parietal peritoneum, which represents a part of the upper border of the falciform ligament of the liver. This fold contains a portion of the obliterated umbilical vein, which is now spoken of as the round ligament of the liver. It extends upwards from the umbilicus to the interlobar or umbilical

notch on the anterior border of the liver, through which it passes to enter the umbilical fissure on the under surface of the viscus. As the round ligament ascends to the liver the peritoneum, within which it lies, is being gradually elongated in the form of two closely applied laminæ, which thus project to form a part of the falciform ligament. The apex of this ligament is therefore at the umbilicus.

The Tunica Vaginalis and Testis.

Tunica Vaginalis.—This is a closed serous sac, behind which the testis lies. It is composed of two layers, parietal and visceral. The **parietal layer** is known as the *tunica vaginalis scroti*, from the circumstance that it lines the scrotal chamber of its own side, and it is formed by the lower part of the processus vaginalis or peritoneal diverticulum, which precedes the descent of the testis from the abdominal cavity. It is much larger and looser than the visceral layer, with which it is continuous along the posterior border of the testis and on the spermatic cord about ½ inch above the organ. The **visceral layer** is known as the *tunica vaginalis testis*, and is

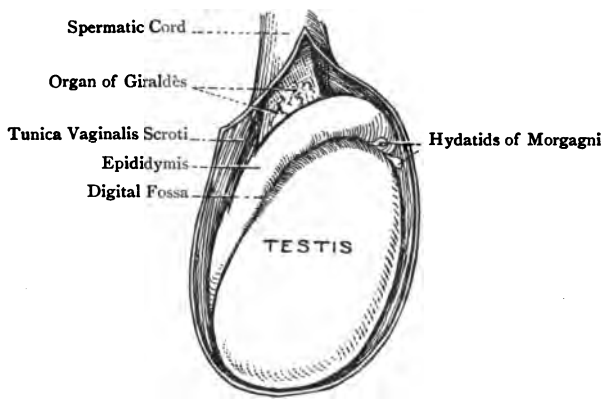


FIG. 286.—THE TESTIS AND ITS COVERINGS.

formed by the primitive peritoneum which covered the testis whilst in the abdominal cavity. It is also known as the *tunica adnata* ('born to'). It closely invests the tunica albuginea of the testis, to which it is inseparably united. It also invests the epididymis except at its posterior border, where the constituents of the spermatic cord enter or leave the testis. Between the epididymis and the testis it forms a recess, called the **digital fossa**, and it extends upwards on the spermatic cord for about ½ inch above the testis. Along the posterior border of the organ, where this layer becomes continuous with the parietal layer, there is a narrow

strip which is free from serous investment. The portion of the tunica vaginalis which is related to the spermatic cord is called the *funicular part.* When fluid accumulates between the parietal and visceral layers the condition is known as hydrocele of the tunica vaginalis.

Testis.—The testis is suspended obliquely by the spermatic cord in its scrotal compartment, to the bottom of which it is loosely attached by the fibrous remains of the gubernaculum testis. The left testis is a little lower than the right. The organ is oval, and compressed from side to side. Its exterior, which is smooth, is closely invested by the visceral layer of the tunica vaginalis, except where the constituents of the cord enter or leave the organ. The surfaces are external and internal, the former looking slightly backwards, and the latter forwards. The extremities are superior and inferior, the former being inclined forwards, and the latter backwards. The borders are anterior and posterior. The anterior border looks slightly downwards and outwards, and is free. The posterior border looks upwards and inwards, and is attached. The average weight of the testis is about 7 drachms.

Epididymis.—This is an elongated narrow body, composed of the convolutions of the excretory duct, and lying along the posterior border and adjacent portion of the external surface of the testis. Its upper extremity, which is above the upper end of the testis, is enlarged, and is called the **caput** or **globus major**; the lower and smaller end is called the **tail** or **globus minor**; and the intervening narrow portion represents the **body.** The globus major and globus minor are connected to the testis by fibrous tissue, and by a reflection of the tunica vaginalis, the former being further connected to the organ by the efferent ducts. The body, except at its posterior border, is free, being separated from the testis by the digital fossa. The epididymis is almost completely invested by the visceral layer of the tunica vaginalis except at its posterior border, where there is a duplicature of that membrane containing bloodvessels and attaching it to the testis.

Hydatids of Morgagni.—These are two small pyramidal bodies which are situated on the anterior aspect of the globus major at its lower part, or on the front of the upper end of the testis below the globus major, one of them being pedunculated and the other sessile. Each is composed of connective tissue and bloodvessels, covered by the visceral layer of the tunica vaginalis. The hydatids are vestiges of Müller's duct.

Organ of Giraldés or **Paradidymis.**—This organ is situated on the front of the spermatic cord, immediately above the globus major, and under cover of the funicular part of the tunica vaginalis. It consists of a few irregular nodules of convoluted tubules, which are lined with ciliated columnar epithelium. These nodules are remains of the Wolffian body.

Arterial Supply of the Testis and Epididymis.—The testis derives its arterial supply from the testicular branch of the spermatic

(which enters the posterior border of the organ), and the epididymis derives its supply from the epididymal branch of the spermatic, which vessel arises from the abdominal aorta about 1 inch below the renal artery. The globus minor of the epididymis also receives a few twigs from the deferential artery, which is usually a branch of the superior vesical from the internal iliac.

The **veins** of the testis issue at the upper part of the posterior border, and, along with those of the epididymis, enter the spermatic cord, where they form the pampiniform plexus. The *right* spermatic vein, in which the right plexus ultimately ends, opens directly into the inferior vena cava, and the *left* into the left renal vein.

Lymphatics.—These ascend in the spermatic cord, and accompany the spermatic vessels as high as the *median group of lumbar glands* in which they terminate.

Nerve-supply.—The spermatic plexus of the sympathetic system, which derives its fibres from the aortic and renal plexuses.

The testis is homologous to the ovary of the female (testis muliebris).

Abnormal Positions of Testis.—The testis may not be situated in the scrotum, its absence therefrom being due to one of three causes: (1) the testis may never leave the abdomen, or its descent may be arrested in the inguinal canal, such conditions being known as *cryptorchismus*; (2) instead of entering the scrotum, it may pass into the anterior part of the perineum; (3) it may leave the abdomen through the crural ring, and, after descending through the crural canal and passing through the saphenous opening, it may take up its position on the front of the thigh, where it might simulate a femoral hernia.

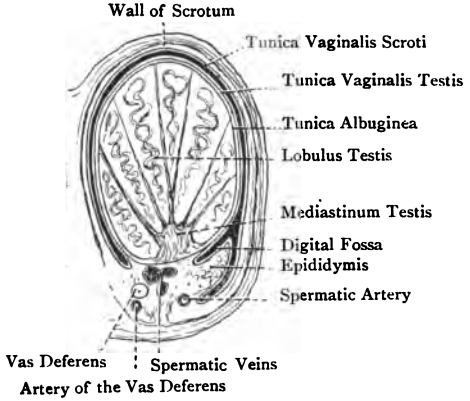


FIG. 287.—DIAGRAM SHOWING A TRANSVERSE SECTION OF THE TESTIS AND SCROTUM.

General Structure of the Testis and Epididymis.—The **testis** is an aggregation of seminiferous tubules collected into lobules, which are encased within a capsule called the *tunica albuginea*. This tunic is a dense, bluish-white, inelastic membrane, composed of bundles of fibrous tissue. Its outer surface is closely covered by the tunica vaginalis testis. Its inner surface is invested by a copious vascular network, known as the *tunica vasculosa of Cooper*. At the posterior border of the testis the tunica albuginea passes for a certain distance into the interior, this inflection being called the **corpus Highmorianum,** or **mediastinum testis.** This mediastinum extends into the organ for one-fourth of its antero-posterior measurement, and from its sides and anterior border a number of trabeculæ, containing plain muscular tissue, pass off, which extend in various directions as far as the inner surface of the tunica albuginea, to which they are attached. By means of these the interior of the testis is mapped out into a number of loculi, the trabeculæ which enclose them

containing the branches of the spermatic artery as they make their way to the tunica vasculosa. These compartments contain the **seminiferous tubules** collected into bundles, called the *lobuli testis*, which vary in number from 300 to 400. Each lobule contains from two to four tubules, and is conical, the base being directed towards the circumference of the testis and the apex towards the mediastinum. Each tubule is about $\frac{1}{120}$ inch in diameter, and is convoluted. When the coils are undone the tubule measures about 2 feet in length. The tubules of each lobule unite into one, and the tubules of adjacent lobules unite in turn, and so give rise to the *tubuli recti*, each of which is about $\frac{1}{400}$ inch in diameter, and about $\frac{1}{10}$ inch in length. These tubuli recti enter the mediastinum, where they form by their division a network, called the *rete testis*. From this rete tubules, called *vasa efferentia*, proceed, which are about $\frac{1}{30}$ inch in diameter, their number varying from twelve to twenty. These leave the testis at the upper part of its posterior border. For a short distance thereafter they remain straight, but they are soon thrown into convolutions, which form conical masses, called *coni vasculosi*. The length of each conus vasculosus is about $\frac{1}{3}$ inch, and its apex is directed towards the testis. When the convolutions are undone, the tube assumes a length of about 8 inches, its diameter gradually diminishing from about $\frac{1}{20}$ inch at its commencement to about $\frac{1}{60}$ inch at its termination. The coni vasculosi open by separate orifices into the canal of the epididymis.

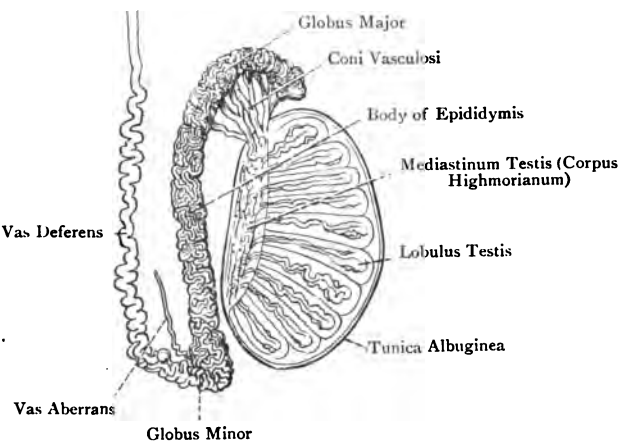


FIG. 288.—THE STRUCTURE OF THE TESTIS AND EPIDIDYMIS.

The **epididymis** consists of one tube, having a diameter of about $\frac{1}{16}$ inch in the globus major, where it commences in a blind extremity. In the body it diminishes a little in diameter, and in the globus minor it again enlarges. The tube presents a great number of convolutions, which, being folded upon themselves and connected together by loose tissue, give rise to a series of lobules. When the convolutions are undone the length of the epididymis has been variously estimated at from 12 to 20 feet. At its upper extremity it receives the coni vasculosi, and beyond the globus minor it terminates in the vas deferens. At the point where it terminates in the vas deferens there is a diverticulum connected with it, called the *vas aberrans of Haller*, which extends upwards in a convoluted manner between the epididymis and the adjacent part of the vas deferens. The vas aberrans, when the coils are undone, is from 8 to 12 inches in length.

Minute Structure.—The **tubuli seminiferi** are composed of a hyaline basement membrane, lining which there are several layers of epithelial cells. The most external layer is known as the *lining epithelium*, and is composed

of cubical cells. Some of these project inwards between the succeeding layers, and are called the *sustentacular cells*. The next layer is formed of large cells, called the *spermatogenic cells*, and these may form more than one layer. The nuclei of these cells show indications of division. The most internal layer, which immediately surrounds the lumen of the tubule, is composed of small cells, called the *spermatoblasts*, from which the spermatozoa are formed. These *spermatozoa* lie with their heads buried between the more deeply placed cells, and their long tails projecting free into the lumen of the tubule. The enlarged ends or heads of the spermatozoa, whilst they lie buried between the deeper cells, are connected with the sustentacular cells of the lining epithelium. The **tubuli recti** are composed of a basement membrane lined with a single layer of cubical epithelium. The **tubules of the rete testis** are destitute of a basement membrane, its place being taken by the connective tissue of the mediastinum. The lining membrane of the tubules consists of a single layer of cubical cells. The **vasa efferentia and coni vasculosi** are composed of a basement membrane, external to which there is a layer of plain muscular fibres arranged in a circular manner. The lining epithelium is of the ciliated columnar variety.

FIG. 289.—THE TUBULI SEMINIFERI OF THE TESTIS (MAGNIFIED).

The **structure of the epididymis** is similar to that of the vasa efferentia and coni vasculosi.

Development of the Testis.—In connection with the development of the testis the following embryonic structures fall to be described, namely, the Wolffian duct, the Wolffian body, and the germinal epithelium and genital ridge.

Wolffian Duct.—This duct is developed in connection with a portion of mesoblast situated between the paraxial mesoblast and the pleuro-peritoneal cavity, and known as the **intermediate cell-mass.** In the very early embryo (from the second to the third week) a longitudinal cord makes its appearance, which is formed by a segmentation of mesoblastic cells from the intermediate cell-mass. This cord is at first solid, and in close proximity to the epiblast, from which circumstance it is regarded by some authorities as being of epiblastic origin. It soon, however, acquires a lumen, and is then known as the Wolffian duct. The posterior or caudal end of this duct opens into the posterior (lower) portion of the ventral or uro-genital compartment of the cloaca (the common opening of the uro-genital ducts and hind-gut).

Wolffian Body.—This body takes the form of a number of tubes, called **segmental tubes,** which are developed in the mesoblast of the intermediate cell-mass, these tubes being transversely disposed at right angles to the Wolffian duct. They are at first solid, but each is subsequently provided with a lumen, and by one extremity they open into the Wolffian duct. The Wolffian body attains its greatest development about the eighth week.

Germinal Epithelium and Genital Ridge.—The peritoneal epithelium on the inner side of the Wolffian body and Wolffian duct undergoes a thickening and segmentation, and so forms what is known as the *germinal epithelium*; and the portion of mesoblast covered by it forms a ridge, called the *genital ridge*. The germinal epithelium increases in thickness, and its more deeply placed cells multiply and invade the genital ridge, where they lie embedded in groups. It is from these cell-groups in the genital ridge that the **seminiferous tubules** of the testis, with their several layers of lining cells, as well as the Graafian follicles and ova in the female, are developed. Preparatory to the formation of the seminiferous tubules the cells embedded in the genital

ridge become disposed in columns which anastomose with each other in a reticular manner. In the meshes of this network large cells make their appearance, known as the *primordial sperm cells*, which, after division and subdivision, ultimately lose their identity. The cell-columns now become converted into tubules, which represent the seminiferous tubules of the body of the testis. The other constituents of the testis, namely, the **tubuli recti, rete testis,** and **vasa efferentia,** are developed as outgrowths from the anterior segmental tubes of the Wolffian body, whilst the **coni vasculosi** are developed from those parts of the involved anterior segmental tubes which open into the Wolffian duct. The tubuli recti now join, and become continuous with, the seminiferous tubules, the junction taking place about the third month. The **epididymis** is developed from the *anterior* or *cephalic part* of the Wolffian duct, and the **vas deferens** and **common ejaculatory duct** are developed from the *posterior* or *caudal part*. The **vas aberrans of Haller** and the **paradidymis** or **organ of Giraldés** are persistent remains of the *more posterior tubes* of the Wolffian body which have not taken part in the development of the testicular tubules. The tunica albuginea of the testis and the interstitial stroma of the organ are developed from the mesoblastic connective tissue of the genital ridge. The **hydatids of Morgagni** are vestiges of *Muller's duct.*

ABDOMINAL CAVITY.

The abdominal cavity is somewhat ovoid, the vertical measurement greatly exceeding the transverse. Its superior boundary is formed by the diaphragm, which here presents a concave surface. The inferior boundary is formed by the levatores ani and coccygei muscles, covered superiorly by the visceral pelvic fascia and inferiorly by the anal fascia. This boundary is concave on its upper aspect. The superior and inferior boundaries, being fleshy, are capable of contracting and relaxing alternately. During contraction the diaphragm descends on each side, and the levatores ani ascend, thus diminishing the vertical measurement of the cavity. During relaxation the reverse takes place, the diaphragm ascending and the levatores ani descending, and so the cavity is increased in its vertical measurement. The anterior and lateral boundaries are partly osseous and partly musculo-aponeurotic. The osseous boundaries are formed by the lower ribs above, and the pelvis below. Elsewhere these boundaries are formed by the musculo-aponeurotic planes of the abdominal muscles. The posterior boundary is formed by the bodies and discs of the lumbar vertebræ, psoas magnus and quadratus lumborum muscles with their fascial investments, sacrum, and coccyx. The cavity is divided into two regions, the abdomen proper and the pelvis. The **abdomen proper** is limited below by the brim of the pelvis, and its visceral contents are the abdominal portion of the alimentary canal, with the exception of the pelvic colon and rectum, the liver, pancreas, spleen, kidneys, and suprarenal bodies. The **pelvis** is situated below the level of the brim, and contains the pelvic colon, rectum, and internal uro-genital organs.

Abdomen Proper.

Division into Regions.—The abdomen proper is divided into nine regions by means of two horizontal and two vertical lines, with their

corresponding planes. The horizontal lines are called subcostal and intertubercular. The **subcostal line** encircles the abdomen proper on a level with the lowest parts of the tenth costal cartilages, and the plane corresponding to it is called the **subcostal plane**. The **intertubercular line** connects the highest points of the iliac crests which can be felt from the front, where there is usually a tubercle on the outer lip about 3 inches from the anterior superior iliac spine. The plane corresponding to this line is called the **intertubercular plane**. The vertical lines are called the **Poupart lines**, right and left, and each extends vertically upwards from the centre of Poupart's ligament. The planes corresponding to these lines are known as the **Poupart planes**. The subcostal and intertubercular lines, with their corresponding planes, map out the abdomen proper into three horizontal zones, called subcostal, umbilical, and hypogastric. The two Poupart lines, with their corresponding planes, subdivide each of these zones into three regions, two lateral, right and left, and a central. The abdomen proper is thus eventually divided into nine regions, three in each of the three horizontal zones, as follows: the **subcostal zone** is subdivided into *right hypochondriac*, *epigastric*, and *left hypochondriac regions;* the **umbilical zone** is subdivided into *right lumbar*, *umbilical*, and *left lumbar regions;* and the **hypogastric zone** is subdivided into *right iliac*, *hypogastric*, and *left iliac regions*.

Superficial View of the Contents.—On taking a superficial view of the contents of the abdomen proper the sharp anterior border of the liver is seen on the right side projecting beyond the right costal margin, and also beyond the ensiform process. The great bulk of the organ, however, lies concealed in the right hypochondrium, and the extent to which it passes into the left hypochondrium usually corresponds to the left mammary line. In the middle line it projects beyond the ensiform process for about 2 inches, but along the right costal margin it does not usually project more than about $\frac{1}{4}$ inch. The anterior border presents two notches. One, which is well defined, is called the **interlobar** or **umbilical notch.** It is situated fully 1 inch to the right of the middle line, and transmits the obliterated umbilical vein or round ligament. The other, which is situated about 2 inches to the right of the interlobar notch, is usually somewhat indefinite, and is called the **cystic notch.** It allows the fundus of the gall-bladder to come forward opposite the ninth right costal cartilage at a point coinciding with the outer border of the right rectus muscle. The falciform or suspensory ligament is conspicuous as it takes attachment to the supero-anterior surface of the liver, which it divides into two lobes, right and left.

On the left side a portion of the stomach is visible, though a large part of the viscus lies deeply in the left hypochondrium. The portion which is seen in the epigastrium is partially covered by the left lobe of the liver, but a part of it is in contact with the anterior abdominal wall, provided the viscus is not empty.

Descending from the great curvature of the stomach there is an extensive fold of peritoneum, which hangs down in the form of a curtain, and so conceals the subjacent viscera. This fold is called the **great** or **gastro-colic omentum.** In normal circumstances it descends as low as the level of the sacral promontory upon the left side, but it stops a little short of that level on the right side. The condition of the great omentum is subject to much variety. In some bodies it is very narrow, and much puckered in the vertical direction, so as to leave exposed the viscera which are normally covered by it. In other cases it is displaced to one or other side, or it may even be raised into the left hypochondrium. In normal circumstances a few coils of the ileum are visible beyond the great omentum on the right side, and, more especially in the female, one or two loops may descend into the pelvic cavity to occupy the pouch of Douglas. In the right iliac fossa the cæcum is in part seen, and in the left iliac fossa the iliac colon is partially visible.

When the great omentum is raised and laid over the costal margin the coils of the jejunum and ileum come into view, occupying the umbilical and hypogastric regions, and extending into the right and left lumbar, and iliac, regions. The transverse colon is also seen crossing in an arched manner from the right to the left hypochondriac regions.

Position, Connections, and Component Parts of the Stomach.—The stomach occupies a very oblique position, its direction being downwards and to the right. It is situated in the left hypochondrium, within the left costal margin, and also in the epigastrium, the extent to which it encroaches upon the latter region varying according to the degree of distension of the organ. The liver and diaphragm are partly above and partly in front of it, the transverse colon being immediately below it. The viscus has the form of a curved cone, the base being directed upwards and to the left, and the apex downwards and to the right. The right extremity is bent slightly upwards and backwards. The component parts of the stomach are as follows: two extremities, two surfaces, two borders, and two orifices.

The **extremities** are left and right. The **left extremity** is also called the *cardiac* or *splenic end.* It is much enlarged, and lies deeply in the left hypochondrium within the left costal margin. This end forms the *fundus* or great cul-de-sac, and when distended it pushes up the diaphragm, and so encroaches upon the space naturally occupied by the heart and left lung. The upward limit of this part towards the middle line is the sixth left chondro-sternal articulation, and in the left mammary line it reaches as high as the fifth rib behind and above the position of the apex-beat of the heart. The **right extremity** or *pyloric end* is bent slightly upwards and backwards, and presents a small dilatation, called the *antrum pylori* or small cul-de-sac. The pyloric end lies in the epigastrium, and may be overlapped by the quadrate lobe of the liver.

The **surfaces** are anterior and posterior, provided the viscus is empty, but, when it is fully distended, the anterior surface

becomes superior and the posterior surface inferior. In moderate distension the surfaces are antero-superior and postero-inferior. The **antero-superior surface** is in contact from left to right with the diaphragm, the anterior abdominal wall, and the left lobe of the liver. The **postero-inferior surface** corresponds with the crura of the diaphragm, aorta, inferior vena cava, pancreas, spleen, upper extremity of the left kidney, left suprarenal body, and transverse meso-colon.

The **borders** are upper and lower. The **upper border** is known as the **small curvature**, and its direction is upwards and to the right. It extends from the lower end of the œsophagus to the pylorus, and is concave, except near the pylorus, where it becomes

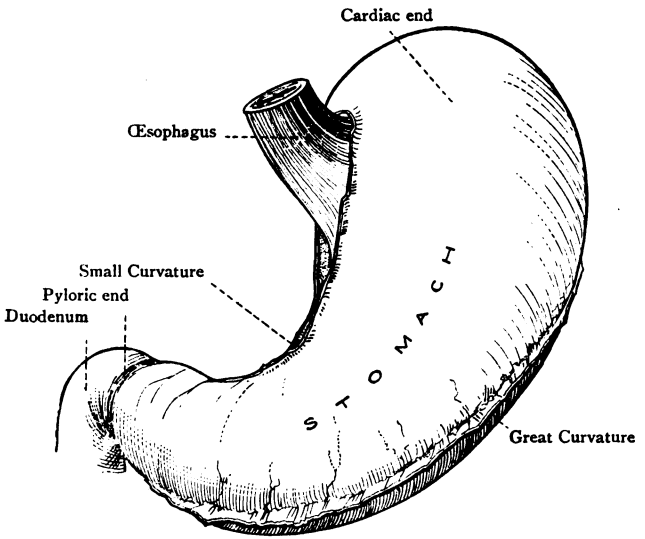


FIG. 290.—THE STOMACH (EXTERNAL VIEW).

convex as it enters into the formation of the antrum pylori. The gastro-hepatic omentum is attached to this border. The **lower border** is known as the **great curvature**, and its direction is downwards and to the left. It is convex, except near the antrum pylori, where it presents a concavity, and the gastro-colic omentum is attached to it.

The **orifices** are called cardiac and pyloric. The **cardiac orifice** or **cardia** is situated at the left end of the small curvature, and about 3 inches from the extreme left end of the viscus. It lies behind the seventh left costal cartilage at a point 1 inch to the left of the sternum, and, relatively to the vertebral column, it is about the level of the tenth or eleventh thoracic vertebra. The

pyloric orifice or **pylorus** is situated at the right end of the stomach, and is nearer the anterior abdominal wall, and on a lower level, than the cardiac orifice. Its position is ascertained by taking a point about 3½ inches below the junction of the body and ensiform process of the sternum, and just to the right of the linea alba. Relatively to costal cartilages it is on the level of a line connecting the tips of the ninth cartilages, and relatively to the vertebral column it is about the level of the twelfth thoracic or first lumbar vertebra.

In the empty state the stomach lies against the posterior wall of the abdomen, and, for an extent corresponding to the cardiac three-fourths, the viscus lies vertically, whilst the pyloric fourth is horizontal. The most movable part of the stomach is the pyloric extremity, the cardiac part being more or less fixed.

Peritoneal Relations.—The stomach is almost completely invested by peritoneum, the anterior surface deriving its covering from the peritoneum of the general cavity, and the posterior surface from that of the small sac. The parts uncovered by peritoneum are as follows: a narrow line along the small curvature between the two layers of the gastro-hepatic omentum for the passage of the gastric and pyloric arteries; a narrow line along the great curvature between the two layers of the gastro-colic omentum for the passage of the right and left gastro-epiploic arteries; and the **uncovered area or trigone.** This latter area is situated on the posterior surface, below, and a little to the left of, the cardiac orifice. It is about 2 inches in breadth, and rather less from above downwards, its shape being triangular. This part of the stomach is in contact with the left crus of the diaphragm, and sometimes with the left suprarenal capsule. The reflection of the peritoneum around this area from the stomach to the diaphragm is known as the gastro-phrenic ligament, which lies on the left side of the lower end of the œsophagus.

For the structure and development of the stomach, see pp. 733, 750.

Position, Connections, and Component Parts of the Intestinal Canal.—The intestinal canal commences at the pyloric end of the stomach and terminates at the anus. It is divided into small intestine and large intestine.

The **small intestine** commences at the pyloric extremity of the stomach, and terminates in the right iliac fossa by opening obliquely into the large intestine. It measures fully 20 feet in length, and is divided into three parts, which, from above downwards, are called the duodenum (twelve fingers' breadth), jejunum ('empty'), and ileum ('coiled'). The **duodenum** is from 10 to 11 inches in length, and its limits are the pyloric extremity of the stomach, and the left side of the body of the second lumbar vertebra. Being very deeply placed, its position and connections will be described further on (p. 685). Of the remainder of the small intestine the upper two-fifths represent the jejunum, and the lower three-fifths the ileum. There is no evident external mark of separation between the three divisions of the small intestine, so that they merge insensibly into each other; but there are internal characters which serve to distinguish these divisions. On the left side of the body of the second lumbar vertebra, where the duodenum terminates in the jejunum, the bowel describes a bend in a downward and for-

ward direction, called the **duodeno-jejunal flexure**, which is suspended from the left crus of the diaphragm by a fibro-muscular band, called the *musculus suspensorius duodeni*. The **jejunum** and **ileum** are very much convoluted, their coils being covered to a greater or less extent by the great omentum. They lie below the transverse colon, and occupy the umbilical, hypogastric, right and left lumbar, and right and left iliac regions. A few coils of the ileum sometimes dip into the pelvis, and when this occurs they occupy, in the female, the pouch of Douglas. The jejunum and ileum are attached to the vertebral column by a fold of peritoneum, called the mesentery proper, which contains their blood-vessels, nerves, and lymphatics, and which is of such a nature as to permit of great mobility in this part of the intestinal tube. They are surrounded by peritoneum except along a narrow interval corresponding with the attachment of the mesentery proper, this border of the bowel being called the attached or *mesenteric border*, as distinguished from the free or *anti-mesenteric border*. The small intestine is a smooth cylindrical tube, which gradually diminishes in size from above downwards. The terminal portion of the ileum, as it is about to join the large intestine, is directed upwards and to the right, with a slight inclination backwards.

Meckel's Diverticulum.—This is a protrusion which is sometimes found connected with the free or anti-mesenteric border of the ileum about 3 feet above the ileo-cæcal valve. It represents the persistent proximal part of the **vitelline** or **vitello-intestinal duct,** which connects the yolk-sac with that portion of the primitive alimentary canal from which the lower part of the ileum is formed. It usually measures from 2 to 3 inches in length, and its calibre generally corresponds with that of the tube from which it springs. In most cases it resembles the finger of a glove, but occasionally it is reduced to the condition of a cord. It is rarely provided with a mesentery.

The **large intestine** commences in the right iliac fossa, and terminates at the anus. It measures about 6 feet in length, and gradually diminishes in size from its commencement to its termination. It is composed of the colon and the rectum. The **colon** is subdivided into the cæcum (with the vermiform appendix), ascending or right colon, hepatic flexure, transverse or middle colon, splenic flexure, descending or left colon, iliac colon, and pelvic colon.

Cæcum.—The cæcum (caput cæcum coli) is the commencement of the large intestine. It represents that part of the gut which extends below the ileo-cæcal orifice, and is situated in the right iliac fossa, where it rests upon the ilio-psoas muscle with the intervention of the fascia iliaca. Its lower end or fundus has an inclination inwards towards the pelvic brim, close to which it usually lies. The average length of the cæcum is about 2½ inches, its breadth being about 3 inches. When empty it is more or less covered by coils of the ileum. In the distended state it comes into contact with the anterior abdominal wall, and at the same time it descends as low as the outer half of Poupart's ligament. At its inner and back part, at a point about 2½ inches from its

lower end, it receives the termination of the ileum, the opening being guarded by the ileo-cæcal valve. The position of this valve corresponds with a point in the right spino-umbilical line between 1½ and 2 inches from the anterior superior iliac spine (*McBurney's point*). In normal cases the cæcum is very movable, being completely covered by peritoneum. The line of reflection of the peritoneum posteriorly may correspond with the level of the ileo-cæcal orifice. In some cases, however, the peritoneum, after having invested the posterior aspect of the cæcum, gives a covering to the posterior wall of the ascending colon for 1¾ inches (Treves), after which the reflection takes place. The line of reflection may be transverse or oblique, and the peritoneum so reflected is continuous with the left or inferior layer of the mesentery proper.

In a few cases (about 6 per cent.) the upper part of the posterior surface of the cæcum is destitute of peritoneum, and is bound down by connective tissue to the subjacent fascia iliaca. Under these circumstances its mobility is more or less curtailed.

Varieties of Cæcum.—The cæcum is characterized by extreme variableness as regards form, but the variations may be grouped into the following four principal types (Treves):

First Type.—In the fœtus the cæcum is conical, the vermiform appendix springing from the apex of the cone. The three longitudinal muscular tæniæ are disposed as follows: one is situated on the postero-internal aspect; a second lies along the postero-external aspect; and the third is placed on the anterior aspect. They are nearly equally distant from each other, and meet at the apex of the cæcum.

Second Type.—The cæcum is quadrilateral. The lower end presents two sacculi, and the vermiform appendix springs from the interval between them. The tæniæ are situated as in the preceding type.

Third Type.—In this variety the part of the cæcum to the *right* of the anterior tænia becomes more developed, and consequently more prominent, than the part to the left of that band, and the anterior wall undergoes greater growth than the posterior wall. During these changes the apex is being gradually shifted backwards and to the left, until finally it takes up a position near the ileo-cæcal junction, where it corresponds with the origin of the vermiform appendix. The part to the right of the anterior tænia becomes so much developed, especially in a downward direction, as to give rise to a false apex. This is the most common form of cæcum, the origin of the appendix being transferred to the left and posterior aspect.

Fourth Type.—In this variety the part to the *right* of the anterior tænia undergoes excessive development, and the part to the left becomes much atrophied, and in many cases practically disappears. This causes the anterior tænia to terminate at the lower part of the ileo-cæcal junction, and the vermiform appendix arises immediately posterior to that point.

Vermiform Appendix.—The vermiform appendix is a small diverticulum of the cæcum, which opens into its inner and back part rather more than 1 inch below the ileo-cæcal orifice. The cæcal end of the appendix is called its **base**, and the guide to it is rather more than 1 inch below McBurney's point. Its diameter corresponds with that of an ordinary goose-quill, and its length varies from 2 to 6 inches, or more. Its outline is serpentine, and the lumen is usually confined to its cæcal half, though it may extend throughout its entire length. The opening by which the appendix

communicates with the cæcum is occasionally guarded by a fold of mucous membrane, which is known as the **valve of Gerlach.** The appendix is provided with a mesentery, called the *appendicular mesentery* or *meso-appendix.* It seldom reaches more than half or two-thirds along the appendix, which latter is thus rendered more or less convoluted or serpentine. The meso-appendix and its variations will be found described on p. 672.

The position occupied by the appendix is extremely variable. According to Lockwood and Rolleston, the normal positions may be tabulated as follows :

1. The vermiform appendix often lies under the left or inferior layer of the mesentery, where it takes a course upwards and to the left in the direction of the spleen. (According to Treves this is its usual position.)
2. It may lie on the brim of the pelvis, or it may project into the pelvic cavity.
3. If the appendicular mesentery is long, the appendix may lie to the right of the cæcum and ascending colon, in which situation it may ascend over the right kidney towards the right lobe of the liver.
4. It may lie free over the cæcum and ascending colon.
5. It may lie free underneath the cæcum. (This is the second most common situation according to Treves.)

As regards abnormal positions of the vermiform appendix, it may, amongst other situations, be found lying in the retro-cæcal, or in the ileo-cæcal, fossa. It has been found extending horizontally across the vertebral column at the level of the lumbo-sacral angle, with its tip resting on the left psoas magnus muscle (Treves).

Ascending or **Right Colon.**—This extends from the cæcum, on a level with the ileo-cæcal orifice, to the under surface of the right lobe of the liver at a point to the right of the gall-bladder. Here it describes a bend, called the hepatic flexure, which indents the liver, and so gives rise to the impressio colica. The ascending colon occupies a part of the right iliac, right lumbar, and right hypochondriac regions, in which it lies deeply, being in contact with the posterior abdominal wall. Posteriorly it rests upon a portion of the right iliacus muscle covered by the fascia iliaca, the right quadratus lumborum invested by its sheath, and the front of the right kidney in its lower and outer part. Anteriorly it is more or less covered by the coils of the jejunum and ileum. Internally, it has the coils of the jejunum and ileum, and the right psoas magnus muscle, covered by its fascia. The ascending colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the ascending meso-colon. Occasionally a peritoneal fold is met with, which extends from the right side of the ascending colon to the abdominal wall at, or a little above, the level of the iliac crest. It is called the *sustentaculum hepatis*, and occurs in about 18 per cent. of cases (Treves). It presents anteriorly a free concave border, and it measures about 1½ inches in width, and about 2 inches from before backwards.

Hepatic Flexure.—This is the bend formed by the gut between

the termination of the ascending colon and the commencement of the transverse colon. The bend takes place in a direction forwards and to the left, and so brings the bowel in front of the second or vertical part of the duodenum. The hepatic flexure has the impressio colica on the inferior surface of the right lobe of the liver above it, the sharp anterior margin of the liver on its outer side, and the second part of the duodenum on its inner side. Posteriorly it is in contact with the right kidney in the same locality as the upper part of the ascending colon, and it is here uncovered by peritoneum.

Transverse or **Middle Colon.**—This, which is comparatively long and very arched, commences in the right hypochondrium in front of the second part of the duodenum, and terminates in the left hypochondrium in the splenic flexure. Its extremities are deeply placed, the right being a little lower and more superficial than the left, and both being comparatively fixed on account of the shortness of the transverse meso-colon at these points. The greater part of it descends into the umbilical region, where it usually lies just above the umbilicus. The transverse colon is completely invested by peritoneum, except occasionally for 1 inch or more posteriorly at its right extremity. The serous membrane forms an extensive fold behind it, called the *transverse meso-colon*, which passes backwards to the anterior border of the pancreas, and is of very limited extent at its right and left extremities. The transverse colon is covered in front by the great omentum. Above it, from right to left, are the liver, gall-bladder, great curvature of the stomach, inferior surface of the pancreas, and basal surface of the spleen; behind it are the second part of the duodenum, head of the pancreas, and transverse meso-colon; and below it are the coils of the jejunum.

Splenic Flexure.—This is situated in the left hypochondrium in contact with the basal surface of the spleen, and behind the cardiac end of the stomach. It occupies a higher and deeper position than the hepatic flexure, and its posterior surface is uncovered by peritoneum. Connected with its left aspect there is a triangular fold of the serous membrane, which attaches it to the diaphragm opposite the tenth or eleventh left rib. This fold is called the *phreno-colic* or *costo-colic ligament*, and it forms a platform upon which the basal surface of the spleen rests: hence the name *sustentaculum lienis* ('support of the spleen'). It will be found described on p. 675.

Descending or **Left Colon.**—This, which is of comparatively small calibre, commences in the left hypochondrium at the splenic flexure, and terminates in the lower part of the left lumbar region on a level with the back part of the iliac crest, where it passes into the iliac colon. It lies deeply in the left hypochondriac and left lumbar regions, being directed at first downwards and slightly inwards, and subsequently vertically downwards. Posteriorly it is in contact, from above downwards, with the front of the left kidney at its lower and outer part, and the left quadratus lumborum muscle invested by its sheath. Anteriorly it is covered by coils

of the jejunum and ileum. Internally coils of the jejunum and ileum form a superficial relation, whilst more deeply there are the lower part of the left kidney and the left psoas magnus muscle covered by its fascia. The descending colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the *descending meso-colon.*

The ascending, transverse, and descending parts of the colon form an arch, within the concavity of which the coils of the jejunum and ileum are disposed.

Iliac Colon.—This commences at the lower extremity of the descending colon on a level with the back part of the iliac crest, and terminates at the inner border of the left psoas magnus, anterior to the left sacro-iliac articulation. At this point it enters the pelvic cavity and becomes the pelvic colon. It is situated in the left iliac fossa, where it lies upon the ilio-psoas muscle with the intervention of the fascia iliaca, its direction being downwards and inwards. Anteriorly it is covered, when empty, by coils of the ileum, but when distended it lies in contact with the anterior abdominal wall. The iliac colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the *iliac meso-colon.*

For the **pelvic colon** and **rectum**, see p. 804.

The large intestine, with the exception of the vermiform appendix and rectum, is characterized by well-marked sacculations, which present a striking contrast to the smooth cylindrical contour of the wall of the small intestine. These sacculations are due to the longitudinal muscular fibres being gathered into three longitudinal bands, called *tæniæ coli* (ligaments of the colon), which are shorter than the portion of bowel to which they are applied. The sacculations are separated from each other by constrictions filled with fat. Another characteristic of the greater part of the large intestine is the presence, at frequent intervals, of small projections of the peritoneal coat containing fat, called *appendices epiploicæ.* These characteristics will be found described in connection with the structure of the large intestine on p. 746.

For the structure and development of the intestinal canal, see pp. 739, 751.

Position, Connections, and Component Parts of the Spleen.—The spleen (lien) is a ductless gland which lies deeply in the left hypochondrium opposite the ninth, tenth, and eleventh ribs, and extending from about the level of the ninth thoracic spine to that of the eleventh. The organ can only be seen when the stomach is drawn out from the left hypochondrium. It is soft, spongy, easily torn, and exceedingly vascular, and it has a dark red colour. It is so liable to become enlarged that it is subject to much variety as regards dimensions and shape. The following statement, therefore,

of its dimensions is only to be accepted as approximately accurate. The average length of the spleen may be said to be about 5 inches, its breadth, at the widest part, being about 3 inches, and its thickness about 1½ inches. The weight, which is very variable, is about 6 ounces. The organ occupies an oblique position, its long axis being directed downwards, outwards, and forwards. Its lower two-thirds are situated in the left hypochondrium, and the upper third in the epigastrium. When it has been hardened *in situ* its shape resembles that of an irregular tetrahedron (Cunningham)—that is to say, it resembles a solid figure enclosed by four equilateral triangles. The following description is based upon this view of its shape.

Apex.—This corresponds with the upper end, and lies in the epigastrium, about 2 inches from the median line. It is directed upwards, inwards, and slightly forwards.

Surfaces.—One aspect of the organ is directed towards the diaphragm, the other looking towards the abdominal cavity and its viscera. The former aspect represents the parietal or external surface, which is convex, and adapts itself to the concavity of the diaphragm. It is called the **phrenic surface,** and its direction is outwards, backwards, and upwards. It is in contact with the diaphragm opposite the ninth, tenth, and eleventh ribs, the left pleural sac descending for some distance between that part of the diaphragm and the adjacent ribs. A part of the base of the left lung, very thin and covered by pleura, also descends for a short distance so as to intervene between the upper part of this surface of the spleen and the exterior. The abdominal or visceral aspect is complex, and presents three surfaces, which are separated from each other by more or less well-marked ridges, radiating from the internal basal angle (Cunningham). These surfaces are called gastric, renal, and basal.

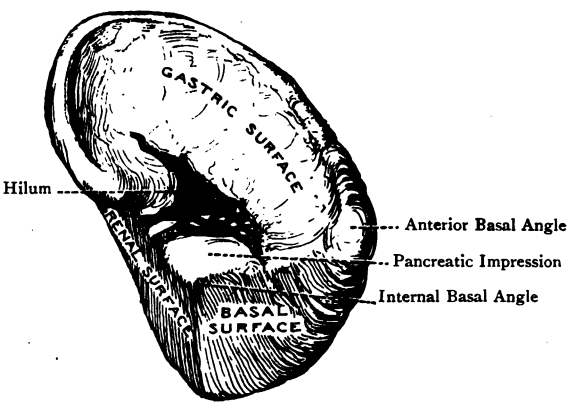


FIG. 291.—THE SPLEEN (VISCERAL AREÆ).

The **gastric surface** is large, concave, and somewhat semilunar. Its direction is forwards, inwards, and downwards, and it accurately adapts itself to the fundus of the stomach on its posterior aspect. It is limited anteriorly by the sharp anterior border of the spleen, which separates it from the phrenic surface, and

posteriorly it is separated from the renal surface by the ridge which extends from the internal basal angle upwards to the apex. A little in front of this ridge, and therefore situated on the gastric surface, there is a fissure, called the **hilum,** for the passage of the splenic vessels, lymphatics, and nerves. Instead of a hilum there is sometimes a row of foramina. The narrow portion of the gastric surface behind the hilum is, at its lower end, in contact with the tail of the pancreas.

The **renal surface,** which is posterior to the gastric surface, is narrow. It is directed inwards and downwards, and is in contact with the front of the left kidney at its upper and outer part, close to the external border. It is separated from the gastric surface by the ridge already referred to, and is limited behind by the posterior border, which separates it from the phrenic surface. Inferiorly it is separated from the basal surface by the ridge which extends from the internal basal angle to the posterior angle.

The **basal surface** is the small triangular surface which looks downwards and inwards. It rests upon the splenic flexure of the colon and upper surface of the sustentaculum lienis or peritoneal platform formed by the costo-colic ligament. It is separated from the renal surface by the ridge already referred to, and from the gastric surface by the ridge which passes between the internal and anterior basal angles. The angles of this surface are called *internal*, *posterior*, and *anterior*, the last being the most prominent.

Borders. — These are anterior, posterior, and inferior. The anterior border is situated between the phrenic and gastric surfaces. It is sharp, and usually presents several notches. The posterior border is situated between the phrenic and renal surfaces. It is blunt, and its position and direction practically coincide with the lowest left intercostal space. The inferior border separates the phrenic and basal surfaces, and is somewhat sharp.

Peritoneal Relations.—The spleen is surrounded by peritoneum, except at the hilum, and where the gastro-splenic omentum and phreno-splenic ligament are connected with it. The serous membrane forms three folds, called gastro-splenic omentum, lieno-renal ligament, and phreno-splenic ligament. The **gastro-splenic omentum** is attached by one extremity to the gastric surface of the spleen just in front of the hilum, the other extremity being connected with the cardiac end of the stomach on its posterior aspect and the left border of the great omentum. The **lieno-renal ligament** is attached by one extremity to the gastric surface along the line of the hilum, the other extremity being attached to the front of the left kidney at its upper and outer part. The **phreno-splenic** or **lieno-phrenic ligament** extends between the spleen near its upper extremity and the contiguous part of the diaphragm.

Occasionally small accessory spleens, varying in number from one to twenty, are found in the gastro-splenic omentum in the neighbourhood of the hilum, or more rarely in the great omentum.

Area of Splenic Dulness.—This area is limited posteriorly by the mid-scapular line between the ninth and eleventh left ribs, and anteriorly by the mid-axillary line as it crosses the ninth, tenth, and eleventh ribs, or by a line connecting the left sterno-clavicular joint with the tip of the eleventh left rib. The length of the area is about 3 inches, and its breadth from 2 to 2½ inches.

For the structure and development of the spleen, see p. 762.

Position, Connections, and Component Parts of the Liver.—The liver (hepar), which is the largest gland in the body, occupies almost all the right hypochondrium, a great part of the epigastrium, and a small part of the left hypochondrium, in which latter direction it usually extends as far as the left Poupart plane. It is maintained in position by the following peritoneal ligaments: the posterior or coronary ligament, the right and left lateral or triangular ligaments, and the falciform or suspensory ligament.

Topography.—The size of the liver is such a variable factor that the following statement of its limits is only to be regarded as approximately accurate. In the right mammary line it extends from a point about ½ inch below the right nipple to a point about ½ inch below the tip of the bony part of the *tenth* right rib, being covered by the right ribs from the fifth to the tenth inclusive. In the mid-axillary line the right aspect of the organ extends from the *seventh* to the *eleventh* rib, and in the scapular line its superior and inferior limits are on a level with the *ninth* and *eleventh* thoracic spinous processes respectively, the ribs to which it is here related being the ninth, tenth, and eleventh. The **left limit** of the organ usually corresponds to the left Poupart plane. In mapping out the **upper limit** the middle line may be taken as the starting-point. In this situation the limit is indicated by a line crossing the sternum at the level of the *sixth* costal cartilages, this line being slightly arched downwards. The line should then be prolonged to the left, with a slight curve upwards, to a point about 2 inches to the left of the left border of the sternum. In continuing the line to the right it should be carried upwards so as to reach a point about ½ inch below the right nipple. The line, on being prolonged from this point towards the right side, must be carried slightly downwards so as to reach the mid-axillary line at the level of the *seventh* right rib. The **lower limit** of the organ extends from a point about ½ inch below the tip of the bony part of the *tenth* right rib to the left extremity of the line indicating the upper limit. The direction of the line indicating the lower limit is upwards and to the left.

Summary of Outline of Liver.—Commencing at a point about 2 inches to the left of the left border of the sternum, draw a line downwards and to the right to the left border of the sternum at the level of the sixth costal cartilage, next across the sternum with a slight curve downwards, then upwards and to the right to a point about ½ inch below the right nipple. From this point carry the line downwards and to the right as far as the seventh rib in the right mid-axillary line, then downwards and backwards to the ninth rib on a level with the ninth thoracic spine, whence the line is carried downwards to the

eleventh rib on a level with the eleventh thoracic spine. From this latter point the line should proceed forwards and slightly upwards to a point about ½ inch below the tip of the bony part of the tenth right rib, and finally upwards and to the left to reach the starting-point.

The liver is to a very large extent under cover of the lower ribs and costal cartilages of the right side, the ensiform process, and the sixth, seventh, and eighth, costal cartilages of the left side. It is accurately moulded on the under surface of the diaphragm, which separates it from the base of the right lung covered by pleura, and the heart enclosed in the pericardium. The thin marginal part of the base of the right lung, with its pleural investment, descends in the angular interval between the diaphragm and the thoracic wall, and so partially covers the liver, a relation which has to be borne in mind in percussing the organ. In the right mammary line the lung descends as low as the *sixth* rib, whilst the liver ascends to the upper border of the *fifth*. In the right mid-axillary line the lung descends as low as the *eighth* rib, whilst the liver ascends as high as the *seventh*. In the right scapular line (inferior angle of scapula) the lung descends as low as the *tenth* rib, whilst the liver ascends as high as the *ninth*. The liver comes nearest to the surface beyond the right costal margin and ensiform process. In the former situation it projects about ½ inch, and in the latter about 2 inches, and in each situation is in contact with the anterior abdominal parietes.

Various circumstances affect the position of the liver. During respiration, the liver descends in inspiration and ascends in expiration. In the horizontal posture it ascends, and in the sitting or upright posture it descends. In distension of the stomach and intestines, as well as in ascites, it ascends. In right hydro-thorax, hypertrophy of the heart, and hydro-pericardium it descends. Long-continued pressure, as in tight lacing, causes the liver to be displaced downwards. Finally, when the abdomen proper is encroached upon by the gravid uterus or by an ovarian tumour the liver is displaced upwards.

The liver has a reddish-brown colour, and presents for the most part a smooth surface. It is firm to the touch, but under pressure is friable, that is to say, easily crumbled. The dimensions of the organ can only be stated approximately. In the transverse direction (from right to left) it measures from 7 to 10 inches, the measurement from before backwards at its right extremity being about 6 inches, which also represents its vertical measurement at the thickest part of the right lobe. Its weight in the adult ranges from 45 to 60 ounces, or from 3 to 4 pounds, the weight in the female being rather less, and its relation to the body weight being in the proportion of one to forty in the adult. In early life the liver is proportionately larger than in the adult, and in a child at the period of birth its relation to the body weight is as one to twenty.

Surfaces.—These are superior, anterior, inferior, right lateral, and posterior. It is not to be supposed, however, that these surfaces are all clearly separated from one another by well-defined borders, only one margin being in reality distinct, namely, the anterior border, which has a very sharp outline.

The **superior surface** is markedly convex in its right portion, and accurately adapts itself to the concavity of the diaphragm with which it is in contact. To the left of this convex part there is a depression, called the *impressio cardica*, produced by the heart with the intervention of the diaphragm. To the left of this impression the superior surface again becomes convex, and adapts itself to the concavity of the left half of the diaphragm. The superior surface is separated from the posterior, anterior, and right lateral surfaces by round, somewhat indistinct, borders.

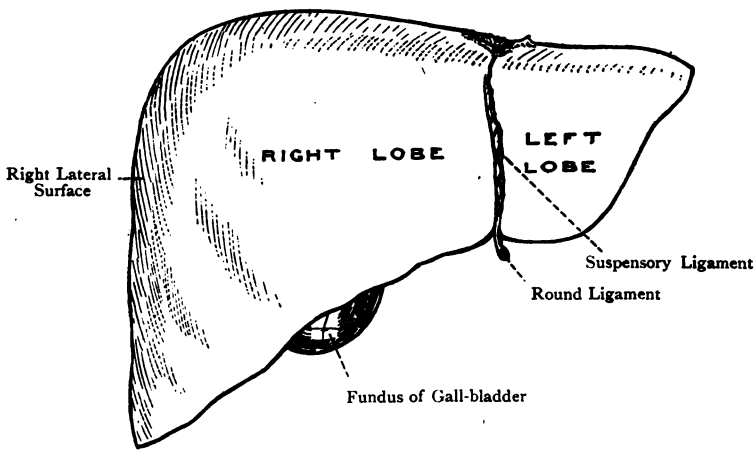


FIG. 292.—THE LIVER (ANTERO-SUPERIOR VIEW).

The **anterior surface** looks forwards and is triangular. The apex is directed towards the left extremity of the liver, whilst the base is towards the right extremity. One side of the triangle corresponds to the anterior border, the other side being formed by the round border which separates the anterior from the superior surface. The anterior surface is mainly in contact with the diaphragm and the right and left costal margins, but at the middle line it is in relation with the ensiform process, and, for about 2 inches below that process, it is in contact with the anterior abdominal wall. The superior and anterior surfaces are divided into two lateral parts by the falciform ligament, the part to the right of this ligament being called the **right lobe**, and the part to the left the **left lobe.** The right lobe forms about four-fifths of the entire supero-anterior surface in the adult, but in early life the two lobes are very nearly of equal size.

The **inferior surface** looks downwards with an inclination to the left. It is divided into two parts, right and left, by the umbilical fissure. The part to the left of this fissure represents a portion of the left lobe. It lies in front of the cardiac orifice

of the stomach, and the anterior surface of that organ close to the small curvature. The part related to the cardiac orifice presents an impression, called the *impressio gastrica*. The part to the right of this impression, close to the back part of the umbilical fissure, presents a smooth round eminence, called the *tuber omentale*. This eminence projects in a backward direction over the small curvature of the stomach, and so abuts against the anterior layer of the gastro-hepatic omentum : hence the name, tuber omentale. The part of the inferior surface to the right of the umbilical fissure presents, as its most striking object, the gall-bladder, which occupies the *cystic fossa*. This fossa extends from the anterior border to the

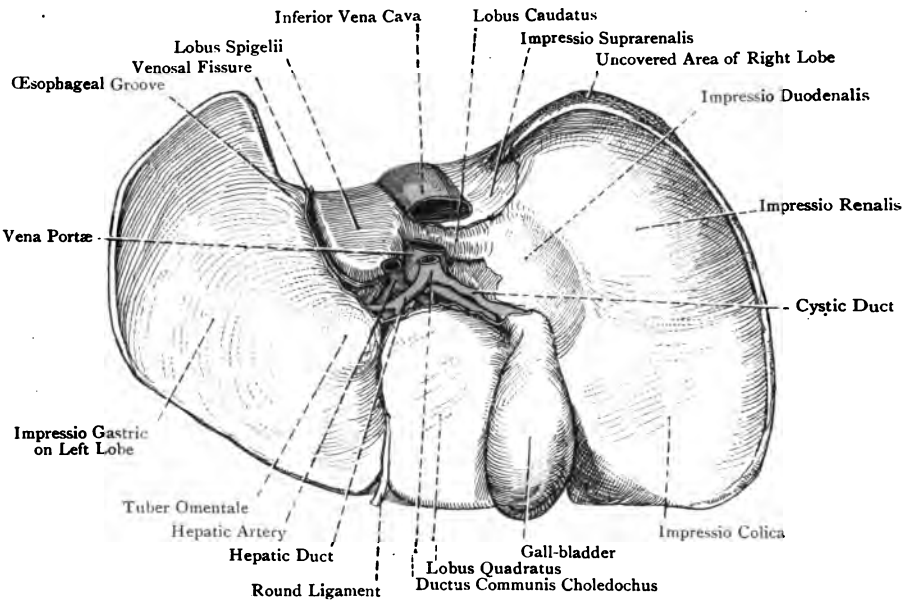


FIG. 293.—THE INFERIOR SURFACE OF THE LIVER.

portal or transverse fissure. It has the quadrate lobe on its left side, and a large part of the right lobe on its right side. The portion of the inferior surface of the right lobe to the left of the gall-bladder includes the following parts: the quadrate lobe, the portal or transverse fissure, the caudate lobe, and the lower margin of Spigel's lobe.

The *quadrate lobe*, which is elongated from before backwards, is bounded anteriorly by the anterior border of the liver; posteriorly, by the portal or transverse fissure; on the right side by the gall-bladder and cystic fossa; and on the left by the umbilical fissure. It is in contact with the pyloric end of the stomach and first part of the duodenum.

The *portal* or *transverse fissure* forms a right angle with the back part of the umbilical fissure, from which it extends over the inferior surface of the right lobe for a distance of about 2 inches. It is bounded in front by the quadrate lobe, and behind by the caudate lobe and the lower margin of Spigel's lobe. The two layers of the gastro-hepatic omentum are attached to its anterior and posterior lips. It serves for the passage of the following structures, in order from before backwards : (1) the hepatic duct ; (2) the hepatic artery, accompanied by the hepatic sympathetic plexus of nerves and lymphatic vessels ; and (3) the vena portæ, all surrounded by the capsule of Glisson.

The *caudate lobe* is the narrow portion of liver substance which connects the right extremity of the lower margin of Spigel's lobe with the adjacent part of the inferior surface of the right lobe. It lies behind the portal fissure, and has the vena portæ in front of it, and the inferior vena cava behind it. It forms the upper boundary of the foramen of Winslow.

The *lower margin of Spigel's lobe*, like the caudate lobe, is situated behind the portal fissure. It is divided by a notch into two eminences of unequal size. The right eminence, which is the smaller of the two, is continuous with the caudate lobe. The left eminence is of large size, and is known as the *tuber papillare*. The part of the inferior surface of the right lobe which lies to the right of the gall-bladder is of large extent, and presents three impressions, namely, impressio colica, impressio renalis, and impressio duodenalis. The *impressio colica*, which looks downwards, is situated in front, where it lies to the right side of the body of the gall-bladder. It is in contact with the hepatic flexure of the colon. The *impressio renalis*, which is of large size, looks backwards as well as downwards, is posterior to the impressio colica, and is in contact with a large part of the front of the right kidney. The *impressio duodenalis* is situated on the inner side of the impressio renalis, just external to the neck of the gall-bladder. It is in contact with the commencement of the second part of the duodenum.

The *umbilical fissure* is so named because it contains the remains of the umbilical vein, now known as the *round ligament of the liver*. It commences at the anterior border of the organ in the umbilical or interlobar notch, and extends as far back as the left extremity of the portal fissure, with which it forms a right angle. It separates the quadrate lobe from the inferior surface of the left lobe. Sometimes the fissure is more or less completely bridged over by a portion of hepatic substance, which thus forms a *pons hepatis*. The obliterated umbilical vein terminates by joining the left division of the vena portæ, and posteriorly the left division of the vena portæ is joined by the obliterated ductus venosus.

The **right lateral surface** is convex, and is in contact with the diaphragm and right ribs from the *seventh* to the *eleventh*, the margin of the base of the right lung and pleura here descending between the ribs and diaphragm as low as the *eighth* rib. There is

no well-marked line of demarcation between this surface and the posterior, superior, and anterior surfaces, but it is distinctly separated from the inferior surface by the right portion of the anterior border.

The **posterior surface** presents a concavity corresponding with the convexity of the bodies of the tenth and eleventh thoracic vertebræ. It is related to the diaphragm, and its component parts from left to right are as follows: the posterior part of the left lobe; the venosal fissure for the ductus venosus; Spigel's lobe, except its lower margin; the caval fossa for the inferior vena cava; and the uncovered area of the right lobe.

The *posterior part of the left lobe* at its left extremity is a mere margin, but elsewhere it presents a distinct surface marked by

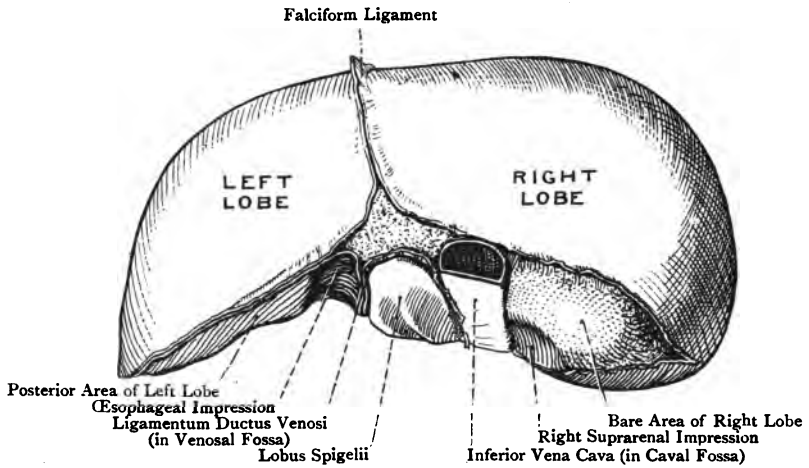


FIG. 294.—THE POSTERIOR SURFACE OF THE LIVER.

the *œsophageal groove*, which is in contact with the right side of the lower end of the œsophagus.

The *venosal fissure* lies vertically on the posterior surface, having Spigel's lobe on its right, and the œsophageal groove of the left lobe on its left. Inferiorly it meets the left extremity of the portal fissure and the posterior extremity of the umbilical fissure, and superiorly it meets the caval fossa. It lodges the obliterated ductus venosus, which is connected below with the left division of the vena portæ, and above with the inferior vena cava. The venosal and umbilical fissures separate the right and left lobes on the posterior and inferior surfaces respectively.

Spigel's lobe, with the exception of its lower margin, lies vertically on the posterior surface. It is bounded on the right side by the caval fossa, on the left by the venosal fissure, and inferiorly by the portal or transverse fissure. It looks backwards and a little

inwards, and is in contact with the right crus of the diaphragm opposite the tenth and eleventh thoracic vertebræ. Its lower margin has been already described (p. 661). The lobe lies at the upper end of the small cavity of the peritoneum.

The *caval fossa* lodges a part of the inferior vena cava. It lies vertically, and somewhat deeply, on the posterior surface, having the uncovered area of the right lobe on its right side, Spigel's lobe on its left side, and the caudate lobe below. This fossa is sometimes bridged over by a portion of liver substance, called a *pons hepatis*. At the upper part of this fossa the hepatic veins open into the inferior vena cava.

The *uncovered area* of the right lobe represents its back part. It measures from 2½ to 3 inches in the transverse direction, and fully 2 inches from above downwards, except at the extreme right, where it tapers to a point. It is destitute of peritoneum, and is enclosed between the two serous layers which form the coronary ligament, being attached to the diaphragm by areolar tissue. Its direction is backwards and a little inwards. The extreme left end of this area, at a point immediately to the right of the lower end of the caval fossa and near the caudate lobe, presents a somewhat triangular impression, called the *impressio suprarenalis*, for the right suprarenal body.

Borders.—The chief borders are three in number, namely, postero-superior, postero-inferior, and anterior. The *postero-superior* and *postero-inferior borders* give attachment to the two layers of peritoneum which form the coronary ligament, and they enclose between them the posterior surface. The *anterior border* is sharp. At its right extremity it passes backwards so as to separate the inferior from the right lateral surface. At its left extremity it also passes backwards, and so forms the thin left margin of the left lobe. Its anterior portion presents two notches, umbilical or interlobar and cystic. The *umbilical* or *interlobar notch* is situated fully 1 inch to the right of the middle line, and transmits the obliterated umbilical vein or round ligament. The *cystic notch*, often hardly perceptible, is situated about 2 inches to the right of the umbilical notch, and allows the fundus of the gall-bladder to come into contact with the anterior abdominal wall.

Peritoneal Relations.—The liver is covered by peritoneum except in the following regions: the uncovered area of the right lobe; a small triangular area at the posterior extremity of the hepatic attachment of the falciform ligament; the portal fissure; and the cystic fossa, unless in those cases where the gall-bladder is completely invested by peritoneum.

For the ligaments of the liver, see p. 673.

Excretory Apparatus of the Liver.—This consists of the hepatic duct, the gall-bladder, the cystic duct, and the common bile-duct.

The **hepatic duct** is formed by the union of a right and left branch which issue from the respective lobes at the portal fissure. It is the most anterior of the structures in that fissure, and, after

a course of rather more than 1 inch downwards and to the right, it joins the cystic duct, and so gives rise to the common bile-duct. The diameter of the hepatic duct is about $\frac{1}{6}$ inch.

The **gall-bladder** is a reservoir for the bile. It is pyriform, and is situated obliquely on the inferior surface of the right lobe, where it occupies the cystic fossa, having the quadrate lobe on its left side, and a large part of the right lobe on its right side. It extends from the anterior border of the liver to near the portal fissure, and presents a fundus, body, and neck. The *fundus*, which is round, looks downwards, forwards, and to the right. It occupies the cystic notch on the anterior border, and is in contact

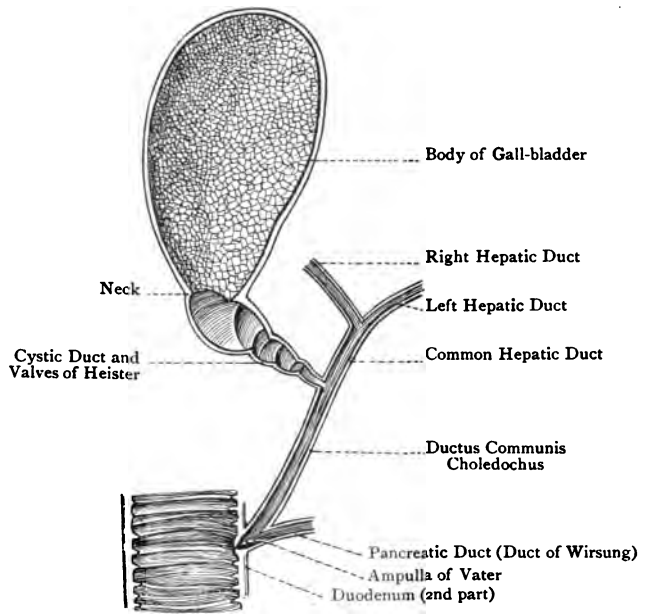


FIG. 295.—THE EXCRETORY APPARATUS OF THE LIVER.

with the anterior abdominal wall opposite the *ninth* right costal cartilage, at the outer border of the right rectus abdominis muscle. The *body* is directed upwards, backwards, and to the left. Its inferior and lateral surfaces are free, but superiorly it is attached by areolar tissue to the cystic fossa. It rests upon the right end of the transverse colon and the first part of the duodenum. The *neck* describes two curves like the letter **S**, after which it is continued into the cystic duct. The gall-bladder is usually covered by peritoneum, except on its upper surface. Sometimes, however, the serous membrane entirely surrounds it and forms a ligamentous fold above it, by which it is loosely and movably suspended

from the cystic fossa. The gall-bladder measures about 3 inches in length, its breadth at the widest part being 1½ inches. Its capacity is from 1 to 1½ ounces. For the structure of the gall-bladder, see p. 758.

The **cystic duct** is about 1½ inches long, its diameter being about $\frac{1}{12}$ inch. Its course is backwards, downwards, and to the left, and it ends by joining the hepatic duct near the portal fissure to form the common bile-duct.

The **common bile-duct** (ductus communis choledochus) is formed by the union of the hepatic and cystic ducts near the portal fissure. Its length is fully 3 inches, its diameter being about ¼ inch. It passes downwards between the two layers of the gastro-hepatic omentum in front of the foramen of Winslow, where it has the hepatic artery on its left side, and the vena portæ behind. It afterwards descends behind the first part of the duodenum, and subsequently between the second part of the duodenum and the head of the pancreas on their posterior aspect. It then enters the wall of the second part of the duodenum in company with the duct of the pancreas, and runs obliquely in the wall for ¾ inch. Thereafter it joins the pancreatic duct, and the resulting duct forms a dilatation, called the *ampulla of Vater*, which, having become constricted, pierces the mucous membrane and opens on the tip of the bile-papilla at the junction of the inner and posterior walls of the second part of the duodenum, where the upper two-thirds and lower third of that part meet. The distance of this opening from the pylorus is about 4 inches. The common bile-duct sometimes opens into the duodenum independently of the pancreatic duct, but close to it.

It is in the ampulla of Vater where a gall-stone may become lodged and delayed in its downward progress towards the duodenum.

Liver in Early Life.—The size of the liver in early life is much greater than in the adult, the left lobe in particular assuming large dimensions. As age advances, however, the left lobe undergoes a marked diminution in size.

For the structure and development of the liver, see pp. 753, 757.

Peritoneum.—The peritoneum is the serous membrane which lines the abdominal parietes, and invests more or less completely most of the viscera. It is composed of two layers, parietal and visceral, the contiguous surfaces of which are smooth and moist. In the male the interval between the two layers forms a shut sac, but in the female, at the fimbriated extremity of each Fallopian tube, the sac communicates with the lumen of that tube, and through it with the cavity of the uterus and the vagina. It is at the margin of the fimbriated extremity of each Fallopian tube where the endothelium of the peritoneum undergoes a sudden transition into the columnar ciliated epithelium of the Fallopian tube.

The peritoneum forms certain reflections or folds which are of three kinds, namely, omenta, mesenteries, and ligaments.

An **omentum** is *a double fold of peritoneum passing between two abdominal viscera.* The omenta are three in number, namely, the great or gastro-colic omentum (epiploön), which passes between the great curvature of the stomach and the transverse colon, the small or gastro-hepatic omentum, which passes between the small curvature of the stomach and the portal fissure of the liver, and the gastro-splenic omentum, which passes between the posterior surface of the cardiac end of the stomach and the gastric surface of the spleen.

A **mesentery** is a *double fold of peritoneum passing between a portion of intestine and the abdominal wall.* The mesenteries in the adult are normally as follows: the mesentery proper, which connects the jejunum and ileum to the vertebral column; the appendicular mesentery or meso-appendix, which is connected with the vermiform appendix; the transverse meso-colon, which extends between the transverse colon and the posterior wall of the abdomen at the anterior border of the pancreas; and the pelvic meso-colon, which connects the pelvic colon to the anterior surface of the sacrum as low as the third sacral vertebra. Occasionally the ascending colon, descending colon, and iliac colon are each provided with a mesentery, called respectively the ascending meso-colon, descending meso-colon, and iliac meso-colon.

A **ligament** is *a fold of peritoneum which connects a viscus not intestine to the abdominal or pelvic parietes.* The peritoneal ligaments are as follows: (1) the ligaments of the liver, namely, the falciform ligament, the coronary ligament, and the right and the left lateral or triangular ligaments; (2) the gastro-phrenic ligament; (3) the lieno-phrenic ligament; (4) the false ligaments of the urinary bladder, namely, two posterior, two lateral, and superior; and (5) the broad ligaments of the uterus.

Course of the Peritoneum.—The parietal and visceral layers of the peritoneum are in unbroken continuity with each other, and this continuity is shown by tracing the membrane in the vertical and transverse directions.

Vertical Course.—Commencing at the portal fissure of the liver two layers of peritoneum descend to the small curvature of the stomach, forming the gastro-hepatic omentum. On reaching the small curvature these two layers separate, one passing over the anterior surface, and the other over the posterior surface, of the stomach. At the great curvature they come together, and descend in the form of a curtain over the coils of the jejunum and ileum to the lower part of the abdomen, forming the two anterior or descending layers of the gastro-colic omentum. These two layers are then folded backwards and ascend to the transverse colon, thus forming the two posterior or ascending layers of the gastro-colic omentum. On reaching the transverse colon they separate, one layer passing in front of, and above, the bowel, and the other layer below and behind it. Having enclosed the transverse colon, the two layers meet, and are prolonged backwards to the posterior

wall of the abdomen at the anterior border of the pancreas, thus forming the transverse meso-colon. On reaching the anterior border of the pancreas the two layers of the transverse meso-colon take leave of each other, and form an ascending and a descending layer. The **ascending layer** passes upwards over the anterior surface of the pancreas, the second part of the duodenum, and the posterior portion of the under surface of the diaphragm,

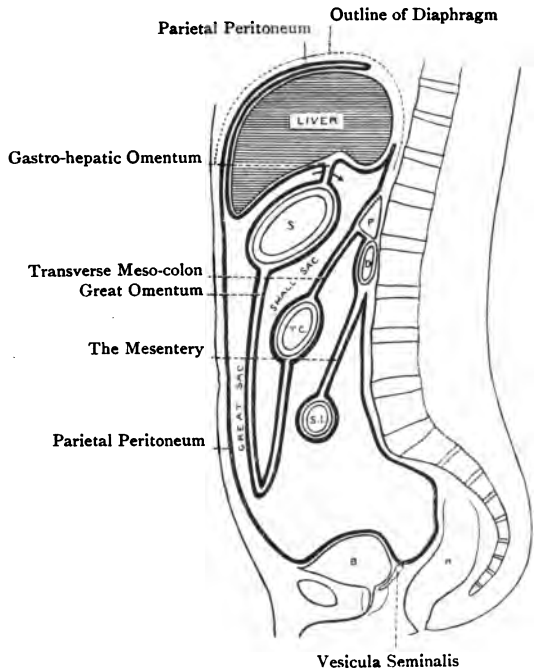


FIG. 296.—DIAGRAM OF THE PERITONEUM IN THE ADULT MALE (VERTICAL SECTION).

S. Stomach
P. Pancreas
D. Duodenum
T.C. Transverse Colon
S.I. Small Intestine
B. Urinary Bladder
R. Rectum

The arrow is through the Foramen of Winslow.

from which it passes to the postero-inferior border of the liver, thus forming the inferior layer of the coronary ligament. Having covered Spigel's lobe, it arrives at the posterior lip of the portal fissure, where it is continuous with the posterior layer of the gastro-hepatic omentum.

The **descending layer** of the transverse meso-colon passes at first backwards upon the inferior surface of the pancreas, and then downwards over the third part of the duodenum, at the lower border of which it is conducted off to the jejunum and ileum by the

superior mesenteric vessels. Having surrounded these portions of the small intestine it passes to the posterior abdominal wall upon the other aspect of the superior mesenteric vessels, and so forms the mesentery proper. It then descends over the abdominal aorta and inferior vena cava into the pelvis, where its course will be subsequently traced. From the apex of the urinary bladder this layer of the peritoneum is reflected on to the posterior surface of the anterior abdominal wall, after lining which it passes to the anterior portion of the under surface of the diaphragm, whence it is reflected on to the postero-superior border of the liver, thus forming the superior layer of the coronary ligament. It then passes over the superior and anterior surfaces of the liver, and, turning round its anterior border, it arrives at the anterior lip of the portal fissure, where it is continuous with the anterior layer of the gastro-hepatic omentum.

Transverse Course. — The peritoneum may be traced in the transverse direction at two levels, namely, above the transverse colon, or at the level of the foramen of Winslow, which is situated behind the right or free border of the gastro-hepatic omentum, and below the transverse colon, or at the level of the umbilicus.

Above the Transverse Colon, or *at the Level of the Foramen of Winslow.*—In front of the foramen of Winslow there are the two layers of peritoneum, anterior and posterior, which form the right or free border of the gastro-hepatic omentum, and which contain between them the common bile-duct, the hepatic artery, and the vena portæ. Tracing the gastro-hepatic omentum from this point to the left, its two layers separate to enclose the stomach, after which they pass to the gastric surface of the spleen as the gastro-splenic omentum. The two layers of this omentum are anterior and posterior, and they contain between them the vasa brevia of the splenic artery. At the spleen the two layers are immediately in front of the hilum. The anterior layer now takes temporary leave of the posterior layer, and turns completely round the spleen, covering its gastric, basal, phrenic, and renal surfaces in succession. On leaving the renal surface of the organ it again passes to the gastric surface, but it is now behind the hilum. Here it meets the posterior layer of the gastro-splenic omentum, which had remained meanwhile stationary immediately in front of the hilum. These two layers now pass backwards to the anterior surface of the left kidney at its upper extremity, and close to its external border, thus forming the lieno-renal ligament. The two layers of this ligament are disposed as right and left, and between them are the splenic branches of the splenic artery. The right layer corresponds with the posterior layer of the gastro-splenic omentum, and the left layer with the anterior layer of that omentum. The *right layer* of the lieno-renal ligament, after leaving the left kidney, passes to the right over the aorta and inferior vena cava. As it covers the latter vessel it is placed *behind* the foramen of Winslow.

It then continues its course to the right, and, having given a partial covering to the front of the right kidney, it passes over the right lateral and anterior wall of the abdomen as far as the middle line. The *left layer* of the lieno-renal ligament, after leaving the left kidney, passes over the left lateral and anterior wall of the abdomen, and, on arriving at the middle line, it becomes continuous with the right layer, which has just been traced as far as the middle line. Along the posterior surface of the anterior wall of the abdomen in the middle line, above the level of the umbilicus, the peritoneum meets with the obliterated umbilical vein or round ligament

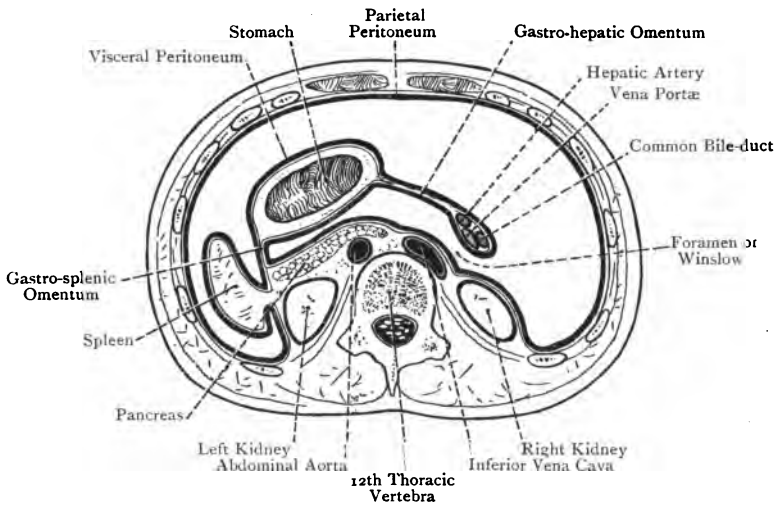


FIG. 297.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE FORAMEN OF WINSLOW (TRANSVERSE SECTION).

of the liver, around which it is reflected, and here it is carried off from the abdominal wall to form part of the falciform or suspensory ligament.

Another way to trace the peritoneum transversely at the level of the foramen of Winslow is to commence just behind that foramen. Beginning at this point, the peritoneum, which covers the inferior vena cava, passes to the right, and, having given a partial covering to the front of the right kidney, it is continued over the right lateral wall of the abdomen, and thence over the right half of the anterior wall. At the middle line, above the level of the umbilicus, it meets with the obliterated umbilical vein or round ligament of the liver, around which it is reflected, and here it is carried off from the abdominal wall to form part of the falciform or suspensory ligament. It then continues its course over the left

half of the anterior abdominal wall and the left lateral wall, whence it passes on to the front of the left kidney at the upper part, close to the external border. From this point it passes to the right over the posterior wall of the abdomen, covering the aorta and inferior vena cava, and so it arrives at a point behind the foramen of Winslow. Between the left kidney and the hilum of the spleen the peritoneum forms the lieno-renal ligament, and between the gastric surface of the spleen, just in front of the hilum, and the posterior aspect of the cardiac end of the stomach it forms the gastro-splenic omentum. The two layers of this omentum, having separated, enclose the stomach. They then meet at the small curvature to form the gastro-hepatic omentum, the layers of which, when followed to the right, arrive at the front of the foramen of Winslow.

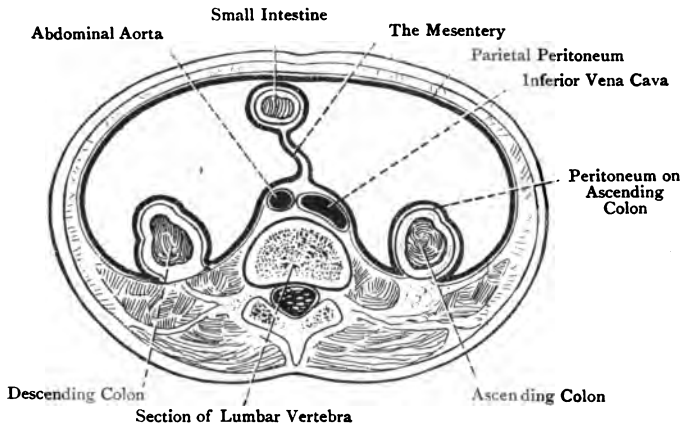


FIG. 298.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE UMBILICUS (TRANSVERSE SECTION).

Below the Transverse Colon, or *at the Level of the Umbilicus*.—Commencing at the middle line and passing to the right, the peritoneum covers the right half of the anterior abdominal wall and the right lateral wall as far as the lumbar region. It then covers the right side, anterior surface, and left side of the ascending colon, whence it passes over the front of the right kidney at its lower and inner part. Thereafter it is reflected over the inferior vena cava, and, meeting with the superior mesenteric vessels, it is carried off by them to the jejunum and ileum, both of which it invests. It is then conducted back again to the vertebral column by the superior mesenteric vessels, thus forming the mesentery proper. It next passes to the left over the aorta, and, having partially covered the front of the left kidney at its lower and inner part, it meets with the descending colon in the left lumbar region, which it covers on the right side, anterior surface, and left side. Thereafter it is

reflected over the left lateral and left half of the anterior wall of the abdomen as far as the middle line.

The relations of the peritoneum to the duodenum, pancreas, and kidneys will be described when these viscera fall to be considered.

Omenta.—The **great** or **gastro-colic omentum** (**epiploön**) extends from the great curvature of the stomach and first inch of the first part of the duodenum to the transverse colon, descending in its course usually as low as the pelvic brim, and lower on the *left* side than on the right, which accounts for the greater frequency of an omental hernia on the left side. It covers the coils of the jejunum and ileum. At the great curvature of the stomach it contains between its two layers the right and left gastro-epiploic arteries, and the epiploic branches of these vessels, which are long and slender, descend into it. The great omentum is often of small size, thus leaving many of the coils of the small intestine uncovered, or it may even be displaced into the left hypochondrium. It is composed of *four* layers of peritoneum, two of which descend from the great curvature of the stomach, inseparably united, to the region of the pelvic brim, these being called the *anterior* or *descending layers*. The other two layers, also inseparably united, ascend from the region of the pelvic brim to the transverse colon, these being called the *posterior* or *ascending layers*. Between the two anterior and the two posterior layers there is usually, in healthy persons, a space which represents a part of the small cavity of the peritoneum, and is known as the **bag** or **sac of the great omentum.** In many cases, however, this space is scarcely demonstrable on account of adhesions. It is most conspicuous a little below the great curvature of the stomach.

The **small** or **gastro-hepatic omentum** extends from the small curvature of the stomach and first inch of the first part of the duodenum to the portal fissure of the liver, and also to the venosal fissure. It is composed of two layers of peritoneum which, at the small curvature of the stomach, contain between them the anterior and posterior branches of the gastric and pyloric arteries. For the most part its two layers are inseparably united, but at its right border, which is free, it contains between them the following structures: (1) the common bile-duct to the right side; (2) the hepatic artery, invested by the hepatic plexus of sympathetic nerves, to the left side; (3) the vena portæ, which lies between these two, and on a plane posterior to both; and (4) lymphatic vessels. This right or free border, with the foregoing contents, lies in front of the foramen of Winslow. The left border of the gastro-hepatic omentum is short on account of the oblique position of the stomach, and is attached to the diaphragm between the caval and œsophageal openings. The *anterior layer* of the small omentum is formed by peritoneum belonging to the great sac, and the *posterior layer* by that belonging to the small sac, these two layers becoming continuous with each other round the right or free border of the omental fold in front of the foramen of Winslow.

The **gastro-splenic omentum** extends between the posterior surface of the cardiac end of the stomach and the gastric surface of the spleen just in front of the hilum. It is composed of two layers, anterior and posterior, which are continuous with the two anterior layers of the great omentum. The *anterior layer* is formed by peritoneum belonging to the great sac, and the *posterior layer* by that belonging to the small sac. The fold contains between its two layers the vasa brevia of the splenic artery.

Mesenteries.—The **mesentery proper** is the fold of peritoneum which attaches the jejunum and ileum to the vertebral column. Its vertebral border is called the *root*, and is comparatively short, measuring from 5 to 6 inches in length. Its line of attachment extends from the commencement of the jejunum on the *left* side of the body of the second lumbar vertebra, at the anterior border of the pancreas, to the termination of the ileum in the right iliac fossa, near the right sacro-iliac articulation. This line of attachment passes obliquely from left to right, and in this course the root of the mesentery proper crosses in succession the third part of the duodenum, aorta, inferior vena cava, and right psoas magnus. The other border of the mesentery proper is called the *intestinal border*, and is attached to the jejunum and ileum throughout their whole length. This border is of considerable length, and equals that of the jejunum and ileum. The widening of the mesentery proper takes place gradually, so that it is thrown into a number of folds, an arrangement which accounts for the coils of the jejunum and ileum. Its average breadth, from the root to the intestinal border, is about 8 inches. The fold is composed of two layers of peritoneum, right or superior, and left or inferior. The right or superior layer is continuous with the inferior layer of the transverse meso-colon, and with the peritoneum which covers the ascending colon, whilst the left or inferior layer is continuous with the peritoneum which covers the descending colon. Both layers are formed by peritoneum belonging to the **great sac.** The two layers contain between them the following structures: (1) the superior mesenteric vessels, and the rami intestini tenuis; (2) the superior mesenteric plexus of sympathetic nerves, and its secondary offshoots; (3) the lacteal vessels; and (4) the mesenteric lymphatic glands.

In some cases the mesentery proper presents one or more openings, known as mesenteric holes, which may be congenital or traumatic. If a portion of intestine slipped through one of these holes a mesenteric hernia would result, and, if the hole is situated in one layer only, the herniated portion of intestine would take up a position in the space between the two layers. These openings are liable to be met with in that portion of the mesentery proper which is attached to the lower part of the ileum, within the arch formed by the ileo-colic branch of the superior mesenteric artery and the last ramus intestini tenuis (Treves).

The **appendicular mesentery** or **meso-appendix** is a fold of

peritoneum which is derived from the left or inferior layer of the mesentery proper near the terminal part of the ileum. It is triangular, and usually lies obliquely. Its *right end* reaches in a pointed manner to the ileo-cæcal junction, and its *left end* forms a concave free border which transmits the appendicular vessels and sympathetic plexus of nerves. It seldom extends for more than half or two-thirds along the appendix, which is thus rendered more or less convoluted or serpentine. It may, however, extend along its entire length. In some cases it lies vertically, and then it loses its hold upon the mesentery proper, its attachment being transferred to the cæcum, or right fascia iliaca, or even to the back of the ascending colon. The base of the appendix is sometimes destitute of a mesentery, in which cases that portion of it is closely connected to the posterior aspect of the cæcum. Occasionally the entire meso-appendix is awanting, and then the appendix is found adhering to the back of the cæcum. The meso-appendix may present a small opening through which a portion of bowel may pass and become strangulated. In very rare cases the meso-appendix is disposed in such a manner as to divide the ileo-cæcal fossa into an upper and a lower compartment.

The **transverse meso-colon** is a broad fold of peritoneum which extends between the transverse colon and the posterior abdominal wall at the anterior border of the pancreas. Its layers contain between them the middle colic vessels, sympathetic nerves, and the lymphatics of the transverse colon. Mesenteric holes may be present in the transverse meso-colon, under which circumstances a meso-colic hernia may occur.

The **pelvic meso-colon** is a fold of peritoneum which attaches the pelvic colon to the front of the sacrum. It extends from the inner border of the left psoas magnus (covered by the left fascia iliaca) near the left sacro-iliac articulation to the front of the third sacral vertebra, and its length is such as to render the pelvic colon freely movable. Its line of attachment posteriorly extends obliquely from left to right, and it is composed of two layers disposed laterally, and containing between them the superior hemorrhoidal vessels, sympathetic nerves, lymphatic vessels, and a certain amount of fat.

The ascending colon, descending colon, and iliac colon are each, in normal circumstances, devoid of a mesentery. Occasionally, however, an ascending meso-colon, a descending meso-colon, and an iliac meso-colon are present.

Peritoneal Ligaments—Ligaments of the Liver.—The peritoneal ligaments of the liver are four in number (the round ligament not being regarded as of a peritoneal nature), and they are as follows: the falciform ligament, the coronary ligament, the right lateral ligament, and the left lateral ligament.

The **falciform ligament** is also known as the **ligamentum latum** and **suspensory ligament.** It extends between the inferior surface of the diaphragm and the posterior surface of the anterior abdominal

wall on the one hand and the superior and anterior surfaces of the liver on the other. Its base, which is free, extends from the umbilicus to the interlobar notch of the liver, and contains between its two layers the obliterated umbilical vein or round ligament. The line of attachment of the ligament to the anterior and superior surfaces of the liver map the organ out into a right and left lobe, and along this line the two layers of the ligament separate from each other, the right layer extending over the right lobe and the left over the left lobe. Near the postero-superior border of the liver the two layers of the ligament diverge somewhat abruptly, and leave between them a small triangular area which is destitute of peritoneum. Thereafter they become continuous, on either side, with the superior layer of the coronary ligament.

The **coronary ligament** is also known as the **posterior ligament.** It is composed of two layers of peritoneum, superior and inferior, which are attached to the postero-superior and postero-inferior borders of the liver on the one hand, and the diaphragm on the other. These layers are separated from each other by an interval, which corresponds with the uncovered area of the right lobe of the liver. The *superior layer* is continuous with the falciform ligament, and the *inferior layer* is continuous with the peritoneum which covers the inferior vena cava and the front of the right kidney.

The **right** and **left lateral** or **triangular ligaments** are situated at the extreme right and left ends of the coronary ligament, and are formed by the meeting, at these points, of the two layers of that ligament.

The **round ligament** of the liver, though not a peritoneal ligament, may here be described. It is a fibrous cord formed by the obliterated umbilical vein, and is contained within the base of the falciform ligament between the umbilicus and the interlobar notch of the liver, its course between these points being upwards, backwards, and to the right. At the interlobar notch it enters the umbilical fissure on the inferior surface of the liver, and terminates by joining the left branch of the vena portæ.

The ligament of the stomach is called the **gastro-phrenic ligament.** It is of small size, and extends between the region of the uncovered trigone of the stomach and the inferior surface of the diaphragm, lying immediately to the left of the lower end of the œsophagus.

The **ligaments of the spleen** are two in number, namely, phreno-splenic or lieno-phrenic, and lieno-renal.

The **phreno-splenic** or **lieno-phrenic ligament** is also called the **suspensory ligament.** It extends between the spleen, near its upper extremity, and the contiguous part of the diaphragm. The **lieno-renal ligament** extends from the hilum of the spleen to the front of the left kidney at its upper and outer part. Its direction is backwards, and it is composed of two layers of peritoneum, right and left, which contain between them the splenic branches of the splenic artery. The right layer corresponds with the posterior

layer of the gastro-splenic omentum, and the left with the anterior layer of that omentum.

The **phreno-colic** or **costo-colic ligament** (*sustentaculum lienis*) extends between the splenic flexure of the colon and the diaphragm opposite the tenth or eleventh left rib. It is triangular, and its surfaces are superior and inferior, its anterior border being free. It forms a platform upon which the basal surface of the spleen rests.

The **sustentaculum hepatis** is a fold of peritoneum which is sometimes met with in connection with the ascending colon. (Treves found it in eighteen out of one hundred bodies.) When present it extends from the right side of the ascending colon to the abdominal wall at a point a little above the level of the iliac crest. Its free border looks forwards, and it forms a shelf which supports the right margin of the liver.

Cavity of the Peritoneum.—The peritoneal cavity is divided into two compartments, great and small, which communicate with each other through the foramen of Winslow behind the right or free border of the gastro-hepatic omentum.

The **great cavity** or **sac** is the space which is exposed to view after opening the abdominal cavity. It is separated from the small sac by the liver, gastro-hepatic omentum, stomach, gastro-colic omentum, gastro-splenic omentum, lieno-renal ligament, and transverse meso-colon.

The **small cavity** or **sac** is an offshoot from the great sac, the introversion taking place at the foramen of Winslow. It extends upwards behind the stomach to the posterior part of the inferior surface of the diaphragm and the Spigelian lobe of the liver, and downwards into the gastro-colic omentum, the part of it within that omentum being known as the **bag** or **sac of the great omentum.**

Boundaries of the Small Sac—*Anterior.*—From below upwards, the two anterior or descending layers of the gastro-colic omentum, the posterior surface of the stomach, the gastro-hepatic omentum, and the posterior surface of the Spigelian lobe of the liver. *Posterior.*—From below upwards, the two posterior or ascending layers of the gastro-colic omentum, the transverse colon, the transverse meso-colon, and the ascending layer of the transverse meso-colon. *Superior.*—The posterior part of the inferior surface of the diaphragm. *Inferior.*—The bend of the gastro-colic omentum, where the two anterior or descending layers are folded backwards to become the two posterior or ascending layers. *Left.*—The spleen ; the gastro-splenic omentum ; the lieno-renal ligament ; and the left border of the gastro-colic omentum.

In a great many cases that part of the small sac which is contained within the gastro-colic omentum is very limited in its downward extent, on account of adhesions having formed between the layers of the great omentum.

Foramen of Winslow.—This is the opening by which the great and small sacs of the peritoneum communicate with each other. It is situated behind the right or free border of the gastro-hepatic omentum, on a level with the body of the 12th thoracic vertebra.

Its direction is forwards and to the right, and it admits of the passage of one finger, and in some cases of two fingers. It is, however, often blocked by inflammatory products.

Boundaries—*Anterior.*—The right or free border of the gastro-hepatic omentum, containing between its two layers (1) the common bile-duct, to the right side; (2) the hepatic artery, invested by the hepatic plexus of sympathetic nerves, to the left side; (3) the vena portæ, which lies between these two, on a plane posterior to both; and (4) lymphatic vessels. *Posterior.*—The inferior vena cava covered by peritoneum. *Superior.*—The caudate lobe of the liver. *Inferior.*—The first part of the duodenum, and the hepatic artery in the first part of its course, as it curves forwards and upwards from the cœliac axis. When the foramen is blocked by inflammatory products, if fluid should be effused into the small sac the condition known as *hydrops saccatus* would result. It is possible for a loop of bowel to pass through the foramen, thus forming one variety of internal hernia.

Peritoneal Fossæ or Pouches.—The peritoneum presents in certain situations small pockets, which are known as peritoneal fossæ or pouches. Their importance consists in the fact that a small portion of intestine may enter one or other of them and become strangulated, thus constituting an internal hernia, which, except in the cases of the inguinal pouches, is called a retro-peritoneal hernia. The fossæ, according to their situation, are called duodenal, duodeno-jejunal, peri-cæcal, and inter-sigmoid.

FIG. 299.—DUODENAL FOSSÆ.

Duodenal Fossæ.—Four varieties of duodenal fossæ are met with in connection with the terminal part of the duodenum, namely, inferior duodenal, superior duodenal, para-duodenal, and retro-duodenal (Jonnesco).

The **inferior duodenal fossa** is the most common and largest. It is situated on the left side of the terminal part of the duodenum, and opens *upwards*. It is bounded in front by a thin triangular portion of peritoneum, called the inferior duodenal fold, which presents a free crescentic border or base superiorly. The fossa may admit the thumb, and may be nearly an inch deep. It is said to be present in 75 per cent. of cases (Jonnesco).

The **superior duodenal fossa** is less constant, and of smaller size, than the inferior, and lies about an inch above it. It opens *downwards*, and its orifice faces that of the inferior duodenal fossa. It may admit the tip of a finger. It is bounded in front by a thin triangular portion of peritoneum, called the superior duodenal fold, which presents a free crescentic border or base inferiorly. The fossa is said to be present in 50 per cent. of cases (Jonnesco).

The **para-duodenal fossa** is situated a little to the left of the terminal part of the duodenum. It bounded on the left side by a faint fold of peritoneum, called the inferior mesenteric fold, which is produced by the inferior mesenteric vein.

The **retro-duodenal fossa** is situated behind the terminal part of the duodenum.

Duodeno-jejunal Fossa.—This fossa is situated on the left side of the duodeno-jejunal flexure, and leads upwards and towards the left side. It is

bounded by two free portions of peritoneum, called the duodeno-mesocolic folds, and it has the pancreas above, the left kidney on the left, and the aorta on the right. It is of small size, and may admit the tip of the little finger. It is said to be present in from 15 to 20 per cent. of cases.

Peri-Cæcal Fossæ.—These fossæ are three in number, namely, ileo-colic, ileo-cæcal, and retro-cæcal.

The **ileo-colic fossa** is situated in the angle between the termination of the ileum and the commencement of the ascending colon, in front of the adjacent part of the mesentery proper. It opens *inwards*, and is bounded *in front*

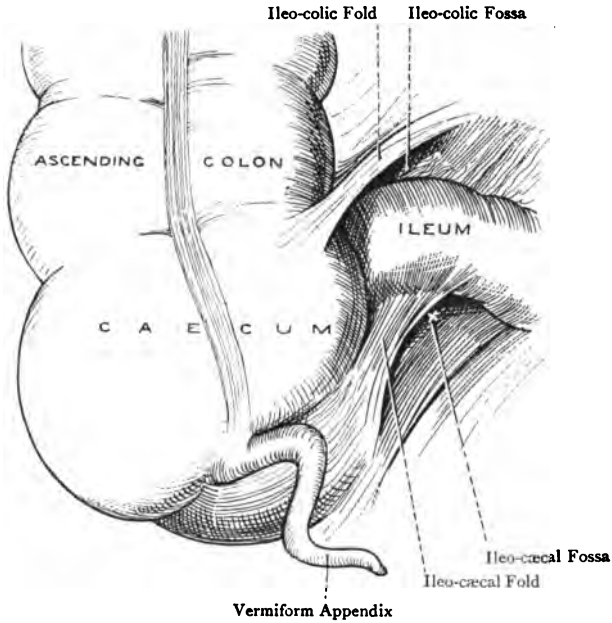


FIG. 300.—ILEO-COLIC AND ILEO-CÆCAL FOSSÆ.

by a portion of peritoneum, called the **ileo-colic fold,** which is produced by the anterior cæcal artery; *behind*, by the mesentery proper; *below*, by the ileum; and, on the *right side*, by the commencement of the ascending colon. In size and depth the fossa is small.

The **ileo-cæcal fossa** is situated in the angle of junction of the ileum and cæcum, and opens downwards and inwards. It may extend upwards for a variable distance behind the ascending colon, and sometimes is capable of admitting two fingers. It is bounded *anteriorly* and *inferiorly* by a portion of peritoneum, called the **ileo-cæcal fold** (bloodless fold of Treves); *posteriorly*, by the meso-appendix; *externally*, by the cæcum; and *superiorly*, by the posterior aspect of the terminal part of the ileum and the inferior layer of the mesentery proper. The importance of this fossa consists in the fact that it often contains the vermiform appendix, or a portion of it.

The **retro-cæcal fossa** is situated behind the cæcum, on the outer side of the meso-appendix. It may extend upwards for a variable distance behind the ascending colon, and is sometimes divided into an external and internal compartment. It occasionally contains the vermiform appendix, or a portion of it.

Intersigmoid Fossa.—This fossa is of rare occurrence in the adult, but is frequently present in early infancy. It is situated on the left side of the pelvic meso-colon near the bifurcation of the left common iliac artery, and is produced by a fold of peritoneum which contains the sigmoid artery. It opens downwards and towards the left side.

The Peritoneum in the Fœtus.—In the fœtus all parts of the abdominal portion of the alimenatry canal from the stomach to the rectum are provided with a mesentery. The mesentery of the stomach is called the **mesogastrium,** and is formed by two layers of peritoneum, which extend between the great curvature (at this period looking backwards) and the posterior abdominal wall, where it encloses the pancreas between its two layers. The transverse meso-colon is distinct from the mesogastrium, though in contact with, and

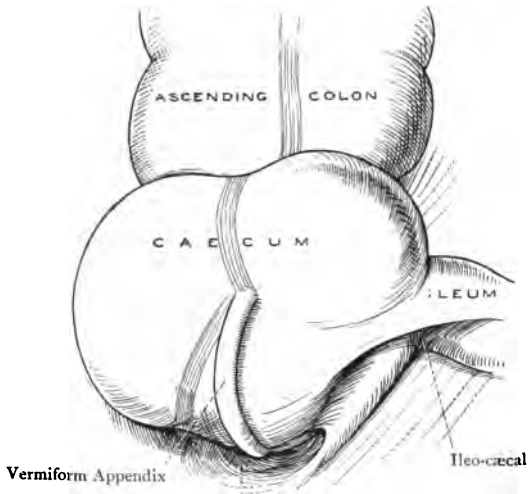


FIG. 301.—THE RETRO-CÆCAL AND ILEO-CÆCAL FOSSÆ.

lying below, it. As the stomach changes its position, the pyloric extremity being tilted forwards and the whole organ turning round upon its right side, the great curvature, which originally looked backwards, is directed downwards and towards the left side. The mesogastrium during this change becomes stretched, and so accommodates itself to the altered position of the organ. Thereafter a gradual extension of the mesogastrium takes place downwards from the great curvature of the stomach over the transverse colon and the jejunum and ileum, and in this manner the great omentum is formed. At first the two posterior or ascending layers of the great omentum pass over the front and upper part of the transverse colon without separating to enclose it, and then backwards to the posterior abdominal wall, lying above the transverse meso-colon. There are thus four layers of peritoneum in this region, the upper two being continuous with the two posterior or ascending layers of the great omentum, and representing the original mesogastrium, and the lower two belonging to the transverse meso-colon. In the latter half of fœtal life the upper two layers become adherent to the upper of the two lower layers of the transverse meso-colon so as to form one layer. The result is that only two layers of peritoneum are now left, instead of the original four. As the result of these changes the pancreas comes to lie *behind* the

peritoneum, whereas it was originally contained between the two layers of the mesogastrium.

The fœtal mesenteries which usually disappear are as follows: the mesogastrium, which is partly developed into the great omentum, and partly incorporated with the upper layer of the transverse meso-colon; the duodenal mesentery; the ascending meso-colon; the descending meso-colon; and the iliac meso-colon.

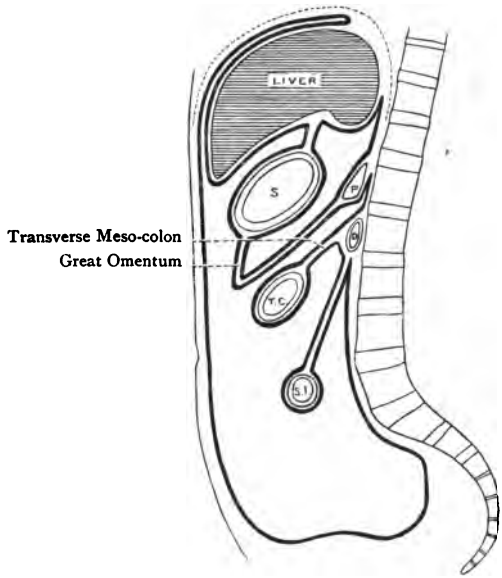


FIG. 302.—DIAGRAM OF THE PERITONEUM IN EARLY LIFE (VERTICAL SECTION).

S. Stomach; P. Pancreas; D. Duodenum; T.C. Transverse Colon; S.I. Small Intestine.

Structure of the Peritoneum.—The peritoneum is a typical serous membrane like the pleura, the serous portion of the pericardium, and the tunica vaginalis. Briefly stated, it consists of a homogeneous connective-tissue basement membrane, containing elastic tissue, and lined with endothelium. Its free surface presents many *stomata* (especially over the diaphragm), which communicate with the cavity of the peritoneum and with the lymph-canalicular system.

Development.—The peritoneum, being a serous membrane, is developed from the walls of the cœlom or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Blood-supply of the Intestinal Canal.—The intestinal canal receives its blood-supply from the superior and inferior mesenteric arteries, with the exception of the upper portion of the duodenum, and a portion of the rectum.

Superior Mesenteric Artery.—This vessel springs from the front of the abdominal aorta about ½ inch below the cœliac axis. It is at first directed downwards behind the neck of the pancreas and the splenic vein. It then passes downwards and forwards in front of the uncinate process of the pancreas and third part of the duodenum, at the lower border of which latter it takes up its position between the two layers of the mesentery proper. The vessel then passes downwards near the root of the mesentery, its course being slightly curved with the convexity towards the left

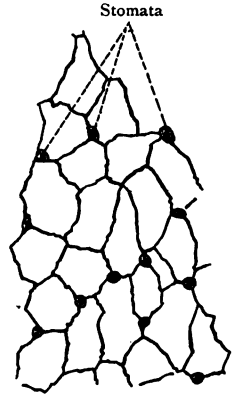


FIG. 303.—ENDOTHELIUM OF A SEROUS MEMBRANE.

side, and it terminates near the ileo-cæcal junction in the last ramus intestini tenuis, which anastomoses with the ileal branch of the ileo-colic artery. The vessel is surrounded by a tough sheath formed by the superior mesenteric sympathetic plexus.

Branches—*Left Branches.*—These are called the **rami intestini tenuis,** and are at least twelve in number. They pass downwards

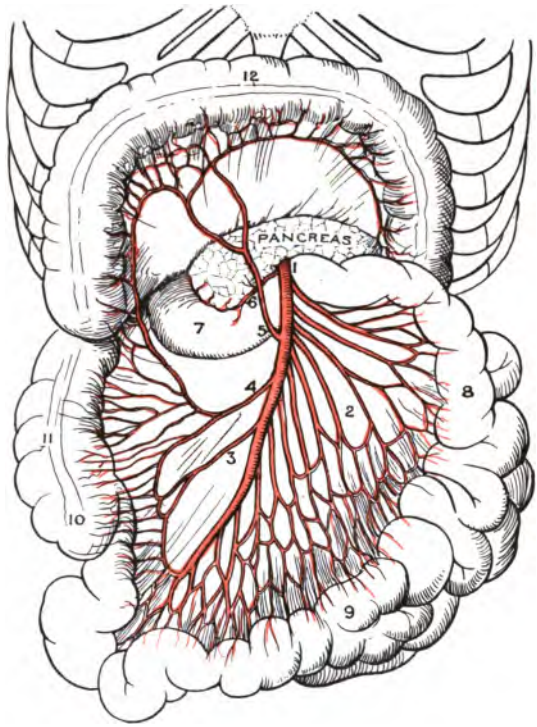


FIG. 304.—THE SUPERIOR MESENTERIC ARTERY AND ITS BRANCHES (AFTER TIEDEMANN).

1. Superior Mesenteric Artery
2. Rami Intestini Tenuis
3. Ileo-colic
4. Right Colic
5. Middle Colic
6. Inferior Pancreatico-duodenal
7. Duodenum
8. Jejunum
9. Ileum
10. Cæcum
11. Ascending Colon
12. Transverse Colon

and to the left *between* the two layers of the mesentery proper, and supply the jejunum and ileum. After a course of about 2 inches each divides into two branches, which by their junction with contiguous branches give rise to primary arches. From the convexities of these arches small branches are given off, which act in a similar manner, and give rise to secondary arches. This disposition of arteries goes on so as to form tertiary, quaternary, and even

quinary arches. The minute vessels arising from the arches of the last tier enter the wall of the jejunum and ileum along the mesenteric border, where each divides into two branches, which encircle the bowel beneath its serous covering. From the rings thus formed branches penetrate deeply to reach the mucous coat. Each ramus intestini tenuis, as well as its various branches, conducts to the bowel an offshoot of the superior mesenteric sympathetic plexus.

Right Branches—**Ileo-colic Artery.**—This vessel is the lowest of the right branches, and in many cases it arises in common with the right colic. Its course is downwards and outwards towards the right iliac fossa *behind* the peritoneum, and it divides into two branches, colic and ileo-cæcal. The *colic branch* passes upwards and forms an arch with the descending branch of the right colic, from which branches proceed to the lower part of the ascending colon. The *ileo-cæcal branch* passes to the upper part of the ileo-cæcal junction, where it furnishes the following branches: *ileal* to the terminal part of the ileum, where it anastomoses with the last ramus intestini tenuis; *appendicular*, which, descending behind the terminal part of the ileum, passes between the two layers of the meso-appendix, and so reaches the vermiform appendix; *anterior cæcal* to the front of the cæcum; and *posterior cæcal* to its posterior aspect.

Right Colic Artery—This is the second branch in order from below upwards, and in many cases it arises in common with the ileo-colic. Its course is transversely to the right *behind* the peritoneum, and it divides into two branches, descending and ascending. The *descending branch* anastomoses with the colic branch of the ileo-colic, and the *ascending branch* with the right branch of the middle colic. The arches thus formed furnish branches to the ascending colon, which in their course form secondary and tertiary arches.

Middle Colic Artery.—This vessel arises from the right side and front of the main trunk about 2 inches above the right colic, on a level with the lower border of the third part of the duodenum. Its course is forwards *between* the two layers of the transverse mesocolon, and it divides into a short right and a long left branch. The *right branch* anastomoses with the ascending branch of the right colic, and the *left branch* with the ascending branch of the left colic from the inferior mesenteric. The arches thus formed furnish branches to the middle colon, which in their course form secondary and tertiary arches.

Inferior Pancreatico-duodenal Artery.—This small vessel usually arises from the right side of the main trunk opposite the upper border of the third part of the duodenum, but it may spring from the first ramus intestini tenuis. Its course is to the right behind the superior mesenteric vein, and between the head of the pancreas and the third part of the duodenum. Thereafter it ascends for a little between the head of the pancreas and the second part of the duodenum, and anastomoses with the superior pancreatico-duodenal of the gastro-duodenal from the hepatic. It supplies the

adjacent portions of the pancreas and duodenum. The vessel is accompanied by an offshoot from the superior mesenteric sympathetic plexus, and, when it arises from the first ramus intestini tenuis, it passes behind the superior mesenteric artery.

Superior Mesenteric Vein.—This vein is formed by tributaries which return the blood from the parts of the intestinal canal supplied by the superior mesenteric artery, and it receives in addition the right gastro-epiploic vein. It ascends on the right side of the superior mesenteric artery. After leaving the mesentery it passes over the third part of the duodenum and uncinate process of the pancreas, and finally behind the neck of the latter organ, where it joins the splenic vein to form the vena portæ. The vessel and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Superior Mesenteric Sympathetic Plexus.—This plexus is derived from the solar plexus. It closely surrounds the superior mesenteric

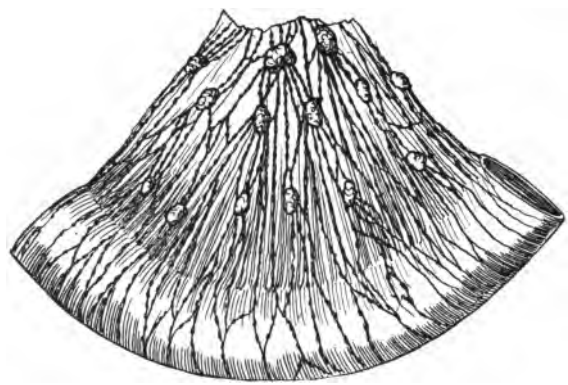


FIG. 305.—PORTION OF JEJUNUM WITH ITS MESENTERY, SHOWING LACTEAL VESSELS AND MESENTERIC GLANDS.

artery in the form of a tough sheath, and it furnishes offshoots which accompany all the branches of that vessel.

Lymphatic Vessels of Small Intestine.—These, which are called **lacteals,** originate in the villi of the mucous membrane of the small intestine (see p. 742). They leave the wall of the bowel at the mesenteric border, those of the jejunum exceeding in number those of the ileum. Within the mesentery they take a course inwards and upwards, becoming, in succession, the afferent and efferent vessels of the groups of mesenteric glands. At the root of the superior mesenteric artery the lacteals, which have now emerged from the innermost mesenteric glands, terminate in from one to four lymphatic trunks, which open into the **receptaculum chyli.**

Mesenteric Glands.—These are about 150 in number, and are situated within the arterial arches, and along the course of the trunk,

of the superior mesenteric artery. In health their average size is about that of a small pea, except along the course of the main artery, where they are somewhat larger, and they are more numerous in the jejunal than in the ileal mesentery. They receive the lacteals from the lower part of the duodenum, the jejunum, and the ileum,

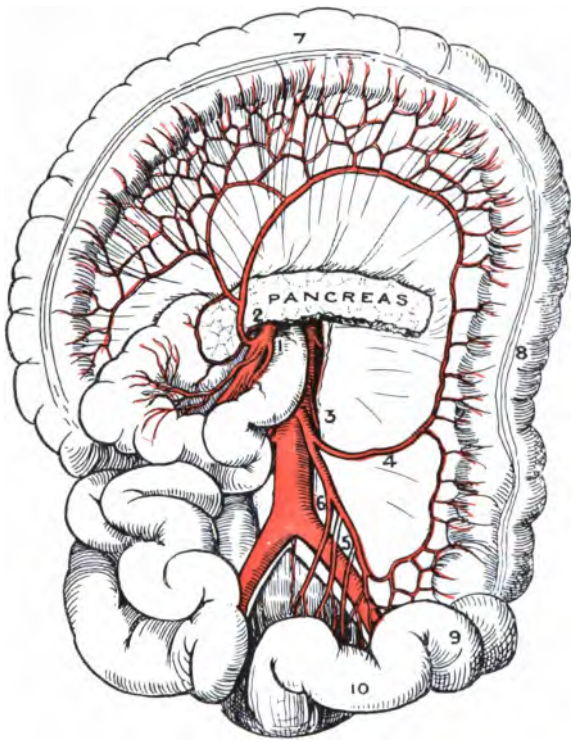


FIG. 306.—THE INFERIOR MESENTERIC ARTERY AND ITS BRANCHES (AFTER TIEDEMANN).

1. Superior Mesenteric Artery
2. Middle Colic
3. Inferior Mesenteric
4. Left Colic
5. Arteriæ Sigmoideæ
6. Superior Hemorrhoidal
7. Transverse Colon
8. Descending Colon
9. Iliac Colon
10. Pelvic Colon

and also the lymphatics from the lower part of the ascending colon. There are no glands in the portion of mesentery close to the intestine for about 2 inches. In the ileo-colic angle there is a special group of glands, called the **ileo-colic glands.** These receive affe ent vessels from the terminal part of the ileum, the cæcum, and the vermiform appendix, and their efferent vessels pass to the innermost group of mesenteric glands.

Lymphatic Vessels of Ascending and Transverse Colon.—The lymphatics of the ascending colon terminate in two ways, as follows: those from the lower part pass to the innermost group of mesenteric glands, whilst those from the upper part go to the meso-colic glands. The lymphatics of the transverse colon become afferent vessels of the meso-colic glands, the efferent vessels of which join the terminal intestinal lymphatic trunks from the mesenteric glands.

Inferior Mesenteric Artery.—This vessel arises from the front of the abdominal aorta towards its left side, about 1½ inches above the bifurcation. Its course is downwards and to the left towards the left iliac fossa. It is *behind* the peritoneum, and lies first upon the aorta, and then on its left side, where it is supported by the psoas magnus. Subsequently it is continued as the superior hemorrhoidal artery over the left common iliac vessels. The artery is surrounded by the inferior mesenteric sympathetic plexus.

Branches—Left Colic Artery.—This vessel passes transversely to the left, *behind* the peritoneum and over the lower part of the left kidney, and it divides into two branches, ascending and descending. The *ascending branch* anastomoses with the left branch of the middle colic, and the *descending branch* with the ascending branch of the superior sigmoid artery. The arches thus formed supply branches to the left extremity of the transverse colon and the descending colon, which in their course form secondary and tertiary arches.

Sigmoid Arteries.—These are usually three in number, superior, middle, and inferior, but they frequently arise as a single trunk. They pass downwards and to the left over the psoas magnus, and supply the lower part of the descending colon, the iliac colon, and the pelvic colon. The *superior sigmoid artery*, which lies, as a rule, *behind* the peritoneum, divides into two branches, ascending and descending. The ascending branch forms an arch with the descending branch of the left colic, and the descending branch passes between the two layers of the pelvic meso-colon, where it anastomoses with the middle sigmoid artery. The *middle* and *inferior sigmoid arteries* pass between the two layers of the pelvic meso-colon, where they form arches with the descending branch of the superior sigmoid, with one another, and with the superior hemorrhoidal artery. The branches of these arches form secondary, or even tertiary, arches before the terminal branches are given off.

The **superior hemorrhoidal artery** is the continuation of the inferior mesenteric, and will be found described on p. 820.

Inferior Mesenteric Vein.—This vein is formed by tributaries which return the blood from the parts of the large intestine supplied by the inferior mesenteric artery. It lies at first near the left side of its artery, but soon leaves it and ascends on the left psoas magnus, where it lies on the left side of the aorta behind the peritoneum. In this course it crosses the left spermatic artery and left renal vein. It finally passes behind the pancreas with an

inclination to the right, and usually terminates in the splenic vein. It may, however, open into the angle of junction of the splenic and superior mesenteric veins, or into the superior mesenteric vein, near its termination. The inferior mesenteric vein and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Inferior Mesenteric Sympathetic Plexus.—This plexus is derived from the left half of the aortic plexus. It forms a tough sheath round the artery, and furnishes offshoots with its branches.

Lymphatic Vessels of Descending, Iliac, and Pelvic Colon.—The lymphatics of the descending colon terminate in two ways, as follows: those of the upper part pass to the meso-colic glands, whilst those of the lower part join the left lymphatic trunk from the median lumbar glands. The lymphatics of the iliac and pelvic colon also join the left lymphatic trunk from the median lumbar glands.

Lymphatic Glands of Large Intestine (colic glands). — These glands are arranged in groups, named according to the portion of intestine to which they are related, and they are situated behind the respective parts, except those belonging to the transverse colon which lie between the two layers of the transverse meso-colon, and are known as the **meso-colic glands.**

Position and Connections of the Duodenum.—The duodenum is the first part of the small intestine. It measures from 10 to 11 inches in length, and is the widest and least movable part. It extends from the pylorus to the left side of the body of the *second* lumbar vertebra, where it ends in the jejunum. It describes a somewhat **U**-shaped curve with the concavity directed upwards and to the left in close adaptation to the head of the pancreas. It is devoid of a mesentery, and is divided into three parts, first, second, and third.

First or **Superior Part.**—The first part extends from the pylorus to the right side of the neck of the gall-bladder. It lies in the epigastric region, and is about 2 inches in length, its direction being upwards, backwards, and to the right when the stomach is empty, but directly backwards when that organ is distended. The gastro-hepatic omentum furnishes a complete covering to about the first inch, and the remainder is covered by peritoneum only in front. The first part is therefore comparatively movable.

Relations—*Superior* and *Anterior.*—The quadrate lobe of the liver and the gall-bladder. *Posterior.*—The vena portæ, gastro-duodenal artery, common bile-duct, and neck of the pancreas. *Inferior.*—The head of the pancreas. The first part lies below the foramen of Winslow.

Second or **Descending Part.**—This part extends from the right side of the neck of the gall-bladder to the right side of the body of the third (sometimes fourth) lumbar vertebra. It lies at first in the epigastric, and subsequently in the umbilical, region; its length is from 3 to 4 inches, and its direction is almost vertically downwards behind the right extremity of the transverse colon. The anterior surface is

covered by peritoneum, except opposite the transverse colon. If there is no transverse meso-colon at this point, there is a distinct strip near the centre left uncovered and connected to the colon by areolar tissue. If, however, there is a transverse meso-colon present at this point, the bare area is trifling. The posterior surface is destitute of peritoneum. The second part is therefore very immovable.

Relations—*Anterior.*—From above downwards the gall-bladder near its neck, the right extremity of the transverse colon, and some coils of the small intestine. *Posterior.*—The anterior surface of the right kidney near the hilum, and the inferior vena cava. *Right.*—The hepatic flexure of the colon, and the right lobe of the liver. *Left.*—The head of the pancreas, with the common bile-duct behind, and the superior pancreatico-duodenal artery in front. The common bile-duct and pancreatic duct enter the wall of this part at the junction of the inner and posterior aspects, a little below the centre.

Third or **Inferior Part.**—This part extends from the right side of the body of the third (sometimes fourth) lumbar vertebra to the left side of the body of the second on a level with its upper border. At this point it makes a sharp bend forwards, and terminates in the jejunum, thus forming the *duodeno-jejunal flexure.* It lies at first in the umbilical, and subsequently in the epigastric, region; its length is about 5 inches, and its direction is at first obliquely to the left and upwards, and afterwards vertically upwards. Its anterior surface is covered by peritoneum derived from the descending layer of the transverse meso-colon, except where it has the superior mesenteric vessels in front of it. There is no peritoneum behind it, and consequently it is fixed in position.

Relations—*Anterior.*—The superior mesenteric vessels and the upper part of the root of the mesentery, with portions of the small intestine on either side of these. *Posterior.*—The inferior vena cava, aorta (below the origin of the superior mesenteric artery), left renal vein, left psoas magnus, and left crus of the diaphragm. *Superior.*—The lower part of the head of the pancreas (including its uncinate process), and the inferior pancreatico-duodenal artery.

The terminal portion of the third part is sometimes spoken of as the *fourth* or *ascending part of Treves.* It is covered by peritoneum on the left side, as well as in front, and in cases where a retro-duodenal fossa is present it is partially covered by peritoneum behind, towards the left side. The duodenal fossæ of the peritoneum are met with on the left side of this portion. The duodeno-jejunal flexure is suspended from the left crus of the diaphragm by a fibro-muscular bundle, called the *musculus suspensorius duodeni.*

Position and Connections of the Pancreas.—The pancreas is a long narrow gland which is situated behind the stomach, on a level with the first and second lumbar vertebræ. Its right extremity occupies the duodenal curve, and its somewhat pointed left ex-

tremity is in contact with the spleen. The greater part of the organ lies in the epigastric region, but its left extremity is situated in the left hypochondrium. The antero-superior surface is covered by the ascending layer of the transverse meso-colon, and the inferior surface by the descending layer, but the posterior surface is destitute of serous covering. The length of the organ is from 6 to 8 inches, its depth from 1 to 1½ inches, except at the right and left extremities, and its thickness from ½ to ¾ inch. Its weight is about 3½ ounces.

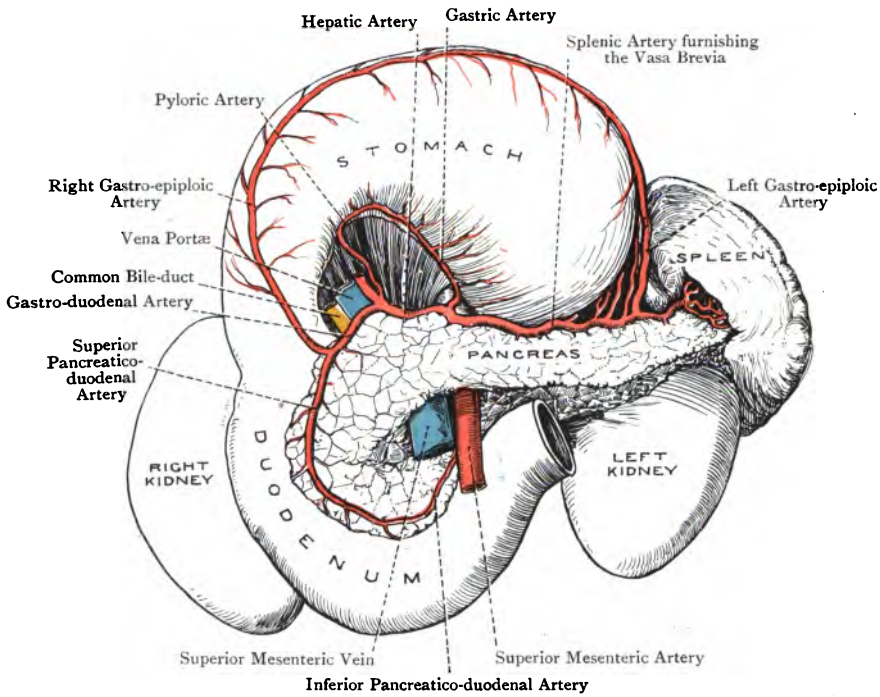


FIG. 307.—THE ARTERIES OF THE STOMACH, DUODENUM, PANCREAS, AND SPLEEN.

It has been likened in shape to the capital letter J laid thus ⊂ (Birmingham). For convenience of description it is divided into a head, neck, body, and tail.

The **head** is the enlarged flattened right extremity. It chiefly corresponds with, and is closely attached to, the second and third parts of the duodenum as far almost as the duodeno-jejunal flexure. The expansion of the head to the left along the upper part of the third portion of the duodenum is called the *uncinate process*.

Relations—*Anterior*.—The transverse colon with its meso-colon, and the superior mesenteric vessels crossing the uncinate process.

Posterior.—The inferior vena cava, right crus of the diaphragm, aorta, and left renal vein. *Superior.*—The first part of the duodenum. *Inferior.*—The third part of the duodenum, and the inferior pancreatico-duodenal artery. *Right.*—The second part of the duodenum, with the common bile-duct behind, as low as a little below the centre, and the superior pancreatico-duodenal artery in front.

The **neck** (Symington) may be defined as the part in front of the origin of the vena portæ and the termination of the superior mesenteric vein. It springs from the anterior surface of the head near its upper part, and is about 1 inch in length. Its direction is upwards and to the left, and it forms the connecting link between the head and body. The gastro-duodenal and superior pancreatico-duodenal arteries occupy a groove on its right side, and the commencement of the first part of the duodenum is in front of it, whilst the origin of the vena portæ and the termination of the superior mesenteric vein are behind it.

The **body** passes to the left, with a slight inclination backwards after it has crossed the aorta. It is triangular, and presents three surfaces—antero-superior, posterior, and inferior, and three borders —superior, anterior, and posterior.

The *antero-superior surface*, which is covered by peritoneum, is in relation with the posterior surface of the stomach. At its right extremity, just below the cœliac axis, it presents a prominence, called the **omental tuberosity** from its relation to the gastro-hepatic omentum. The *posterior surface*, which is destitute of peritoneum, is related to the following structures: the aorta below the cœliac axis, with a portion of the solar plexus; the origin of the superior mesenteric artery; the left suprarenal capsule; and the left kidney with its vessels. The splenic vein passes from left to right in contact with this surface near the superior border. The *inferior surface*, which is covered by peritoneum, is moulded on the duodeno-jejunal flexure, some coils of the jejunum, and the left extremity of the transverse colon. The cœliac axis projects forwards over the *superior border* above the omental tuberosity. To the left of this axis the splenic artery pursues its tortuous course to the spleen, and to the right of it the hepatic artery lies for a short distance. The transverse mesocolon is attached to the *anterior border* along which its separation into ascending and descending layers takes place, the former covering the antero-superior surface of the organ, and the latter, on its way backwards, investing the inferior surface. The *posterior border* presents nothing noteworthy.

The **tail** corresponds with the left extremity where the pancreas is narrowest, and is in contact with the lower end of the gastric surface of the spleen behind the hilum.

For the structure and development of the pancreas, see pp. 759, 762.

Solar or Epigastric Plexus of the Sympathetic System.—The solar plexus is of large size, and is situated deeply in the epigastric region, behind the stomach and in front of the crura of the diaphragm and the aorta close to the origins of the cœliac axis and

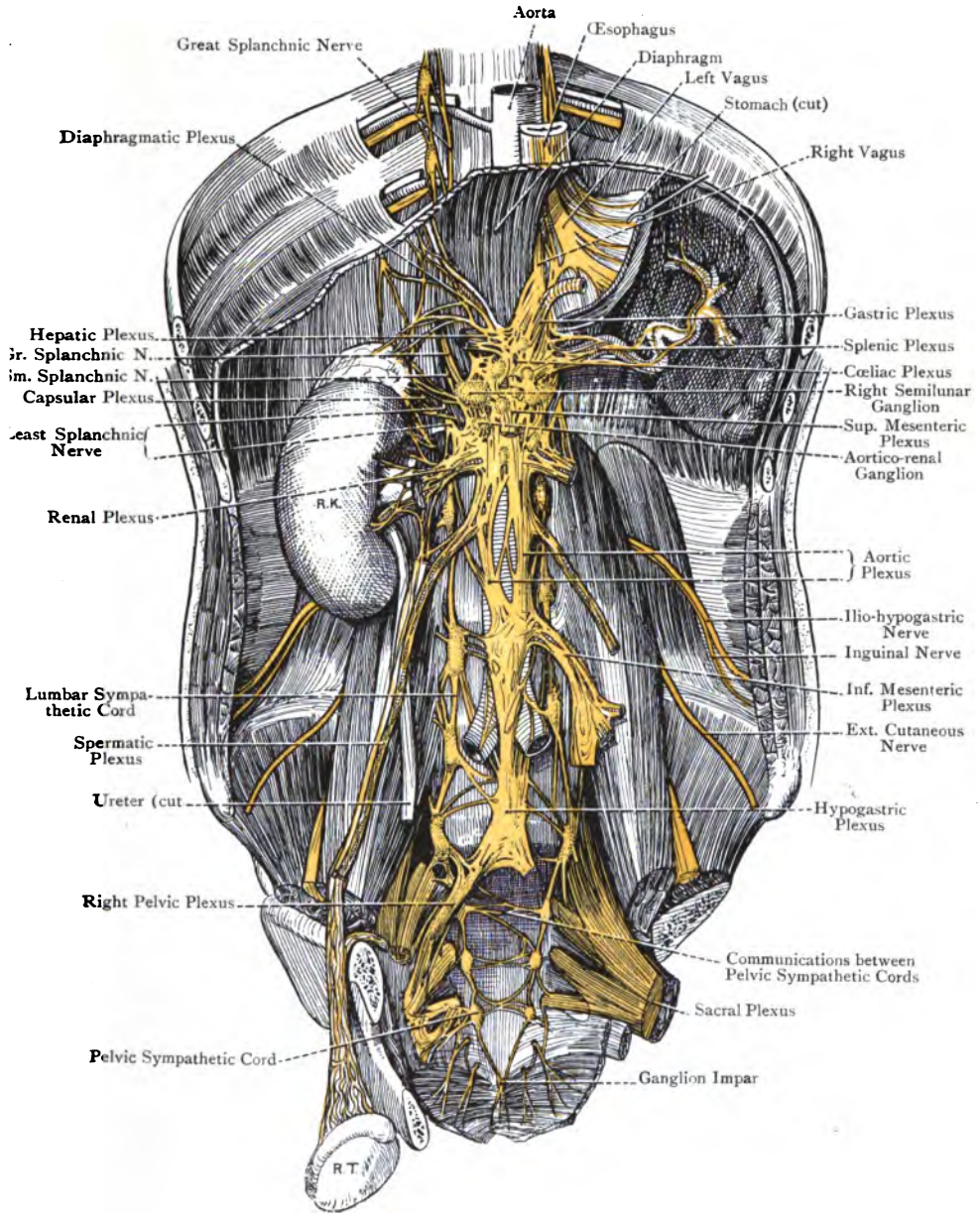


FIG. 308.—THE SYMPATHETIC SYSTEM IN THE ABDOMEN AND PELVIS (HIRSCHFELD AND LEVEILLÉ).

R.K. Right Kidney; R.T. Right Testis.

superior mesenteric artery. It extends from one suprarenal capsule to the other, and is composed of nerve-fibres and ganglia, with an admixture of adipose tissue. The plexus receives its chief fibres from the great and small splanchnic nerves of each side, which contain a large number of spinal fibres. The great splanchnic nerve is formed by roots derived usually from the fifth to the ninth thoracic sympathetic ganglia inclusive, and it enters the abdomen by piercing the crus of the diaphragm. The small splanchnic nerve arises by two roots from the tenth and eleventh thoracic ganglia, and it also enters the abdomen by piercing the crus of the diaphragm. The plexus also receives fibres from the right pneumogastric nerve. Two of the ganglia of the solar plexus are of large size, and are situated one at either lateral pole. They are called the *semilunar ganglia*, right and left. Each lies over the corresponding crus of the diaphragm close to the suprarenal body, that of the right side being under cover of the inferior vena cava, and each receives at its upper part the great splanchnic nerve. The lower part of each ganglion is more or less detached, and is known as the *aortico-renal ganglion*, which lies over the root of the renal artery, and in which the small splanchnic nerve terminates. From each semilunar ganglion branches proceed in a radiating manner upwards, outwards, downwards, and inwards. The inner group of fibres extend from one ganglion to the other, embracing the cœliac axis as they cross the aorta, and forming the cœliac plexus, which receives fibres from the right pneumogastric nerve, and contains numerous small ganglia.

The **cœliac plexus** furnishes three secondary plexuses—gastric, splenic, and hepatic. The *gastric plexus* accompanies the corresponding artery to the small curvature of the stomach, and supplies branches to the adjacent portions of the anterior and posterior surfaces of that organ. The *splenic plexus* goes with the splenic artery, and receives branches from the right pneumogastric nerve. It is distributed, with the branches of the artery, to the pancreas, cardiac extremity of the stomach, left half of its great curvature and adjacent portions of its surfaces, and the spleen. The *hepatic plexus* accompanies the artery of that name, and receives branches from the left pneumogastric nerve. Its distribution corresponds with that of the artery, and its offshoots are as follows: pyloric to the small curvature of the stomach; gastro-duodenal, dividing into right gastro-epiploic to the great curvature of the stomach, and superior pancreatico-duodenal to the head of the pancreas, and the first and second parts of the duodenum; cystic to the gall-bladder; and hepatic to the liver.

The **diaphragmatic** or **phrenic plexus** receives its fibres from the upper part of the semilunar ganglion, and it accompanies the inferior phrenic artery to the diaphragm, giving branches in its course to the suprarenal plexus.

The **suprarenal plexus** receives its fibres from the semilunar ganglion and cœliac plexus. It contains small ganglia, and is

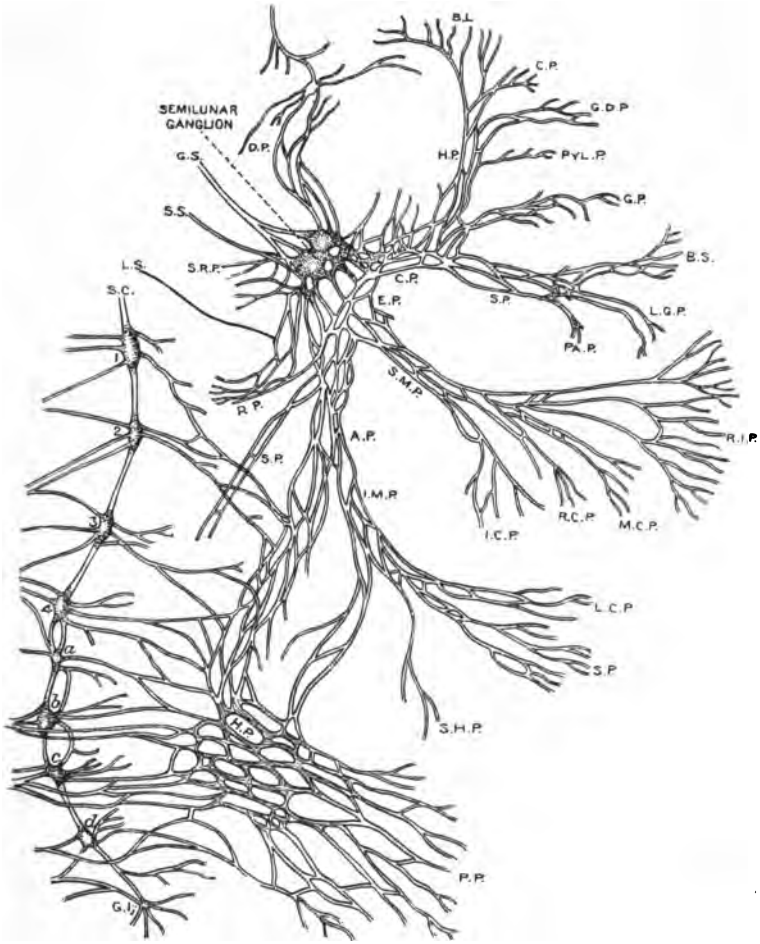


FIG. 309.—SCHEME OF THE SYMPATHETIC NERVE IN THE ABDOMEN AND PELVIS (FLOWER).

S.C. Sympathetic Cord
1,2,3,4. Lumbar Ganglia
a,b,c,d. Pelvic Ganglia
G.I. Ganglion Impar
G.S. Great Splanchnic
S.S. Small Splanchnic
L.S. Least Splanchnic
D.P. Diaphragmatic Plexus
S.R.P. Suprarenal Plexus
R.P. Renal Plexus
S.P. Spermatic Plexus
A.P. Aortic Plexus
I.M.P. Inferior Mesenteric Plexus
L.C.P. Left Colic Plexus
S.P. Sigmoid Plexus
S.H.P. Superior Hemorrhoidal Plexus
H.P. Hypogastric Plexus
P.P. Pelvic Plexus
E.P. Epigastric Plexus
C.P. Cœliac Plexus
S.P. Splenic Plexus
Pa.P. Pancreatic Plexus
L.G.P. Left Gastro-epiploic Plexus
B.S. Branches to Spleen
G.P. Gastric Plexus
H.P. Hepatic Plexus
Pyl.P. Pyloric Plexus
G.D.P. Gastro-duodenal Plexus
C.P. Cystic Plexus
B.L. Branches to Liver
S.M.P. Superior Mesenteric Plexus
I.C.P. Ileo-colic Plexus
R.C.P. Right Colic Plexus
M.C.P. Middle Colic Plexus
R.I.P. Rami Intestini Tenuis Plexuses

joined from above by branches from the diaphragmatic plexus, and below by branches from the renal plexus. It is distributed to the suprarenal capsule.

The **renal plexus** derives its fibres from the aortico-renal ganglion, the cœliac and aortic plexuses, and the least splanchnic nerve when present. (The least splanchnic nerve arises from the twelfth thoracic ganglion, and enters the abdomen behind the ligamentum arcuatum internum, or through the crus of the diaphragm). The fibres of the renal plexus, which contain ganglia here and there, are distributed with the renal artery to the kidney, branches being also given to the suprarenal plexus, spermatic plexus (ovarian in the female), and to the ureter.

The **superior mesenteric plexus** is a continuation of the cœliac plexus, and also receives fibres from the semilunar ganglia. It contains a ganglion, called *superior mesenteric*, in contact with the origin of the artery of that name, and it accompanies that vessel and its branches to be distributed to the intestinal canal from (and including) the third part of the duodenum to the commencement of the descending colon. Its secondary plexuses are as follows: rami intestini tenuis, ileo-colic, right colic, middle colic, and inferior pancreatico-duodenal.

The **aortic plexus** derives its fibres from the semilunar ganglia, and the cœliac and superior mesenteric plexuses. It extends along the aorta, beyond the origin of the superior mesenteric artery, in the form of two lateral strands which communicate freely with one another over the vessel by many interlacing fibres. It is reinforced laterally by branches from the lumbar portion of the gangliated sympathetic cord. The two lateral strands of the plexus ultimately cross the common iliac arteries, and unite in front of the body of the fifth lumbar vertebra to form the hypogastric plexus. The aortic plexus furnishes, on either side, branches to the renal and spermatic (or ovarian) plexuses, and supplies the coats of the aorta. The right strand gives branches to the inferior vena cava, and the left furnishes the chief fibres of the inferior mesenteric plexus.

The **spermatic plexus** derives its fibres from the renal and aortic plexuses, and accompanies the spermatic artery to the testis. In the female it is called the **ovarian plexus,** which goes with the artery of that name to the ovary.

The **inferior mesenteric plexus** is derived chiefly from the left strand of the aortic plexus, and contains a ganglion, called *inferior mesenteric*, which lies below the root of the inferior mesenteric artery. The plexus accompanies the inferior mesenteric artery, and furnishes left colic, sigmoid, and superior hemorrhoidal plexuses, which supply the descending colon, iliac colon, pelvic colon, and rectum.

The **hypogastric plexus** is formed by the fusion of the two halves of the aortic plexus after these have crossed the common iliac arteries. It is reinforced by branches from the lumbar ganglia, and is

situated in front of the body of the fifth lumbar vertebra between the common iliac vessels. It is a large flat plexus, measuring about 1½ inches in breadth, and it ends in two divisions, which become the right and left pelvic plexuses.

Cœliac Axis.—The cœliac axis is a short thick trunk which arises from the front of the aorta between the crura of the diaphragm just below the aortic opening. Its direction is straight forwards over the superior border of the body of the pancreas, and, after a course of about ½ inch, it divides into three radiating branches—gastric, splenic, and hepatic. Of these the splenic is the largest, except during fœtal life when it is exceeded by the hepatic. The branches of the axis supply the stomach, duodenum, pancreas, spleen, liver, and gall-bladder.

Relations.—The right lobe of the liver *above*, the superior border of the body of the pancreas *below*, the gastro-hepatic omentum *in front*, and a semilunar ganglion *on either side*, with the Spigelian lobe of the liver as an additional *right* relation. The axis is closely surrounded by the cœliac sympathetic plexus.

The **gastric** (coronary) **artery** is directed upwards and to the left as far as the small curvature of the stomach on the right side of the œsophagus. It then bends sharply forwards and downwards, and descends in two divisions from left to right along the small curvature towards the pylorus, where it anastomoses with the two divisions of the pyloric branch of the hepatic. The artery is at first behind the small sac of the peritoneum, but along the small curvature it lies between the two layers of the gastro-hepatic omentum, and is surrounded by the gastric sympathetic plexus.

Branches.—These are œsophageal, cardiac, and gastric. The *œsophageal branches* arise when the artery reaches the small curvature, and they ascend through the œsophageal opening of the diaphragm to anastomose on the gullet with the lower œsophageal branches of the thoracic aorta. The *cardiac branches* are distributed to the cardiac end of the stomach, where they anastomose with the vasa brevia of the splenic. The *gastric branches* arise from the two divisions of the artery on the small curvature, and pass to the front and back of the stomach, where they anastomose with branches of the gastro-epiploic arteries.

The **gastric vein** ascends from right to left along the small curvature of the stomach as far as the œsophagus, where it receives a few œsophageal tributaries, after which it turns to the right and opens into the vena portæ.

The **splenic artery** takes a tortuous course to the left along the superior border of the body of the pancreas behind the small sac. On reaching the front of the left kidney it breaks up into several splenic branches which enter the spleen through the hilum. The artery is invested by the splenic sympathetic plexus, and the splenic vein lies below it, and behind the pancreas.

Branches.—These are pancreatic, left gastro-epiploic, vasa brevia,

and splenic. The *pancreatic branches* arise at intervals along the superior border of the pancreas, which they enter. One of them, known as the *arteria pancreatica magna*, enters the organ towards its left end, and passes from left to right, lying a little above the pancreatic duct. The *left gastro-epiploic artery* arises near the spleen, and passes within the gastro-splenic omentum to the great curvature of the stomach, along which it descends from left to right

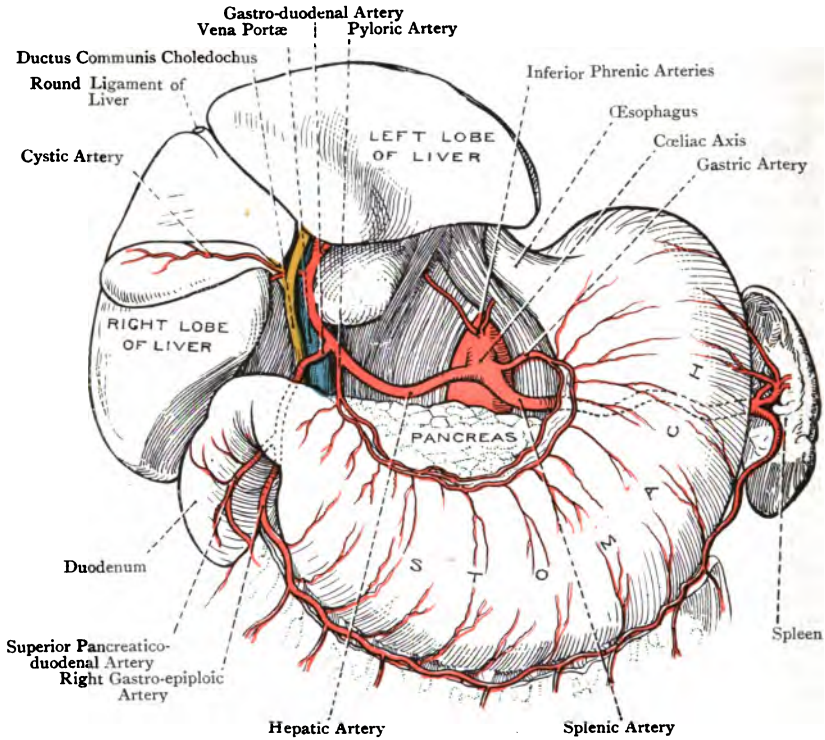


FIG. 310.—THE ARTERIES OF THE STOMACH, LIVER, AND SPLEEN (AFTER MERKEL).

between the two layers of the gastro-colic omentum as far as the centre, where it anastomoses with the right gastro-epiploic. It furnishes *gastric branches* to the front and back of the stomach, which anastomose with branches of the gastric artery, and *epiploic branches*, which descend into the gastro-colic omentum, these latter being long and slender. The *vasa brevia* arise from the terminal part of the splenic and from its splenic branches. They are about five in number, and, having passed within the gastro-splenic omentum to the cardiac extremity of the stomach, they

anastomose with branches of the left gastro-epiploic and gastric arteries. The *splenic branches* are about five in number, and pass to the spleen within the lieno-renal ligament.

The **splenic vein** is formed by the union of about five veins which emerge from the spleen. It is of large size, and passes from left to right behind the pancreas near its superior border, where it lies below the splenic artery. Having crossed the aorta, it joins the superior mesenteric vein to form the vena portæ behind the neck of the pancreas. The vein takes up the following tributaries: the vasa brevia, the left gastro-epiploic, many pancreatic veins, and the inferior mesenteric (as a rule).

The **hepatic artery** passes at first to the right along the superior border of the pancreas for a short distance, where it lies behind the small sac. It then turns forwards *below* the foramen of Winslow to the upper border of the first part of the duodenum near the pylorus, and it subsequently ascends between the two layers of the gastro-hepatic omentum *in front of* the foramen of Winslow towards the portal fissure of the liver, on approaching which it divides into a right and left hepatic branch. The vessel is accompanied by the hepatic sympathetic plexus. As it ascends between the two layers of the gastro-hepatic omentum it has the common bile-duct on its right side, the vena portæ being behind both.

Branches.—These are pyloric, gastro-duodenal, and right and left hepatic. The *pyloric artery*, of small size, arises near the pylorus, and passes to the small curvature of the stomach, where it divides into two branches. These lie between the two layers of the gastro-hepatic omentum, and supply offsets to the front and back of the stomach, which anastomose with the two divisions of the gastric artery. The *gastro-duodenal artery* also arises near the pylorus, and descends behind the first part of the duodenum, having the common bile-duct on its right, and the vena portæ behind it. Having reached the lower border of the first part of the duodenum, it occupies a groove on the right of the neck of the pancreas, and here divides into its two terminal branches—right gastro-epiploic and superior pancreatico-duodenal. The *right gastro-epiploic artery* passes from right to left along the great curvature of the stomach as far as its centre between the two layers of the gastro-colic omentum, and its distribution and anastomoses are similar to those of the left gastro-epiploic artery. The *superior pancreatico-duodenal artery* descends anteriorly between the head of the pancreas and the second part of the duodenum, towards the lower end of which latter it anastomoses with the inferior pancreatico-duodenal of the superior mesenteric. It supplies the first and second parts of the duodenum, and furnishes branches to the adjacent portion of the pancreas. The *hepatic branches* are the terminal divisions of the trunk. The *right*, which is the larger, enters the portal fissure at its right end, whilst the *left*, small in size, enters that fissure at its left end, having previously furnished a branch to

the Spigelian lobe. The right branch gives off the *cystic artery*, and this divides into two branches, superior and inferior, which ramify on the upper and under surfaces of the gall-bladder.

The *pyloric vein* passes from left to right, and opens into the vena portæ near the pylorus.

The *right gastro-epiploic vein* passes from left to right, and opens into the superior mesenteric vein near its termination.

The *pancreatico-duodenal vein* takes up blood from the right end of the pancreas and from the duodenum, and opens into the superior mesenteric vein near its termination.

The *cystic vein* usually ends in the right division of the vena portæ.

All the veins which return the blood from the stomach, duodenum, pancreas, and spleen are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Cœliac Glands.—The glands of this group are numerous. They surround the cœliac axis, and extend over the aorta as low as the origin of the superior mesenteric artery. They receive their afferent vessels from the gastric, pancreatic, splenic, and hepatic glands, and their efferent vessels either join the intestinal lymphatic trunk (or trunks) of the mesenteric glands, or open independently into the receptaculum chyli.

Gastric Glands.—These are arranged in two groups, superior and inferior, the former lying along the small curvature of the stomach, and the latter along the great curvature. They receive their afferent vessels from the stomach, and their efferent vessels pass to the cœliac glands.

Pancreatic Glands.—These lie along the superior border of the pancreas. They receive their afferent vessels from that organ, and their efferent vessels pass to the cœliac glands.

Splenic Glands.—These are numerous, and are situated near the hilum of the spleen in contact with the tail of the pancreas. They receive their afferent vessels from the spleen, and their efferent vessels, having been joined by some of those from the left half of the great curvature of the stomach, pass to the cœliac glands.

Hepatic Glands.—These are situated between the two layers of the gastro-hepatic omentum near the portal fissure. They receive as afferent vessels those of the deep lymphatics of the liver which accompany the branches of the portal vein, and also some of the superficial lymphatics of the inferior surface of the liver, and their efferent vessels pass to the cœliac glands.

Vena Portæ.—This vein is formed by the union of the superior mesenteric and splenic veins, and is about 3 inches in length. It commences on a level with the body of the *first* lumbar vertebra a little to the right of the middle line, where it lies behind the neck of the pancreas and in front of a portion of the head. It ascends behind the first part of the duodenum, and then between the two layers of the gastro-hepatic omentum in front of the foramen of Winslow, where it has anterior to it the hepatic artery and common bile-duct,

the artery being on the left of the duct. When the vessel arrives at the right extremity of the portal fissure of the liver it presents a slight enlargement, called the *portal sinus*, and then divides into two branches, right and left, the former being the larger and shorter of the two. The *right branch*, having received the cystic vein, enters the right lobe of the liver. The *left branch*, having traversed the portal fissure from right to left, and furnished branches to the quadrate and Spigelian lobes, crosses the longitudinal fissure, and

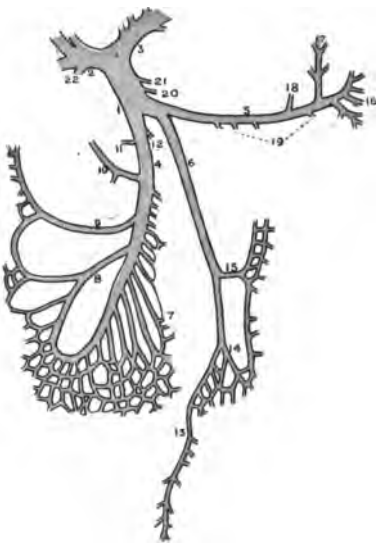


FIG. 311.—VENA PORTÆ AND ITS TRIBUTARIES.

1. Vena Portæ
2. Right Division
3. Left Division
4. Superior Mesenteric
5. Splenic
6. Inferior Mesenteric
7. Rami Intestini Tenuis
8. Ileo-Colic
9. Right Colic
10. Middle Colic
11. Right Gastro-epiploic
12. Pancreatico-duodenal
13. Superior Hemorrhoidal
14. Sigmoid
15. Left Colic
16. Splenic Veins
17. Vasa Brevia
18. Left Gastro-epiploic
19. Pancreatic
20. Pyloric
21. Gastric
22. Cystic

enters the left lobe. As it crosses this fissure it is joined in front by the round ligament of the liver, which is the remains of the umbilical vein of fœtal life. Posteriorly, and slightly to the right of this point, it is connected with the fibrous cord which represents the fœtal ductus venosus. The vena portæ near the pylorus receives the pyloric and gastric veins. The distinctive character of the vessel is that it behaves like an artery, its blood ultimately entering the intralobular plexuses in the liver.

The sources from which the vein receives its blood are as follows :

(1) the stomach, (2) the small and large intestine, except a portion of the anal canal, (3) the pancreas, (4) the spleen, and (5) the gall-bladder.

Summary of the Tributaries of the Vena Portæ.—(1) The superior mesenteric vein, which takes up (*a*) the right gastro-epiploic, (*b*) the pancreatico-duodenal, (*c*) the rami intestini tenuis, (*d*) the ileo-colic, (*e*) the right colic, and (*f*) the middle colic. (2) The splenic vein, which takes up (*a*) the gastric vasa brevia, (*b*) the left gastro-epiploic, (*c*) many pancreatic veins, and (*d*) the inferior mesenteric (as a rule), which in turn takes up the superior hemorrhoidal, sigmoid, and left colic veins. (3) The pyloric vein. (4) The gastric vein. (5) The cystic vein.

The portal vein and its tributaries are destitute of valves, so that the blood can regurgitate in cases of portal obstruction.

Development of the Vena Portæ. — The *lower portion* of the vein results from the union of the two vitelline veins. The *upper portion* is developed from the left half of the lower venous ring and the right half of the upper venous ring, formed by the vitelline veins around the primitive duodenum.

For a description of the **common bile-duct**, see p. 665.

Kidneys.—The kidneys are two in number, right and left, and are situated deeply at the posterior part of the abdomen, where they lie behind the peritoneum. They chiefly occupy portions of the epigastric and hypochondriac regions, but also extend slightly into the umbilical and lumbar regions. Relatively to the vertebral column they extend from the level of the upper border of the last thoracic vertebra to about the centre of the body of the third lumbar, the right kidney being usually somewhat lower than the left. The long axis of each organ is directed downwards and slightly outwards, so that their upper ends are rather nearer the middle line than the lower. The superior limit of the right kidney is usually the lower border of the eleventh rib, whilst that of the left is usually the upper border of the eleventh rib. Inferiorly the organs approach the iliac crests, from which they are distant about 2 inches, the right being the nearer of the two. Each kidney is surrounded by a quantity of areolar and adipose tissues, constituting the adipose capsule, which, along with the adjacent viscera, anchors the organ. The length of a kidney is about 4 inches, the breadth about 2½ inches, and the thickness about 1¼ inches. The right kidney is usually shorter and broader than the left. The weight of the organ is about 5¼ ounces. In form the kidney is bean-shaped. It presents two smooth surfaces, two extremities, and two borders. The anterior surface looks outwards as well as forwards, and presents important visceral impressions, whilst the posterior surface looks inwards as well as backwards, and presents muscular impressions. The extremities are enlarged and round, the superior more so than the inferior, the latter often assuming a somewhat pointed appearance. The external border has an inclination backwards, and is convex and free. The internal border has an inclination forwards, is concave, and is connected with the renal vessels and the pelvis of the kidney.

Relations—*Anterior Surface of the Right Kidney.*—This surface is overlapped by the right suprarenal capsule for a very short distance at its upper and inner part. It presents three visceral areæ—hepatic, duodenal, and colic. The *hepatic area* lies somewhat obliquely, and occupies about the upper two-thirds, being in contact with the impressio renalis on the under surface of the right lobe of the liver.

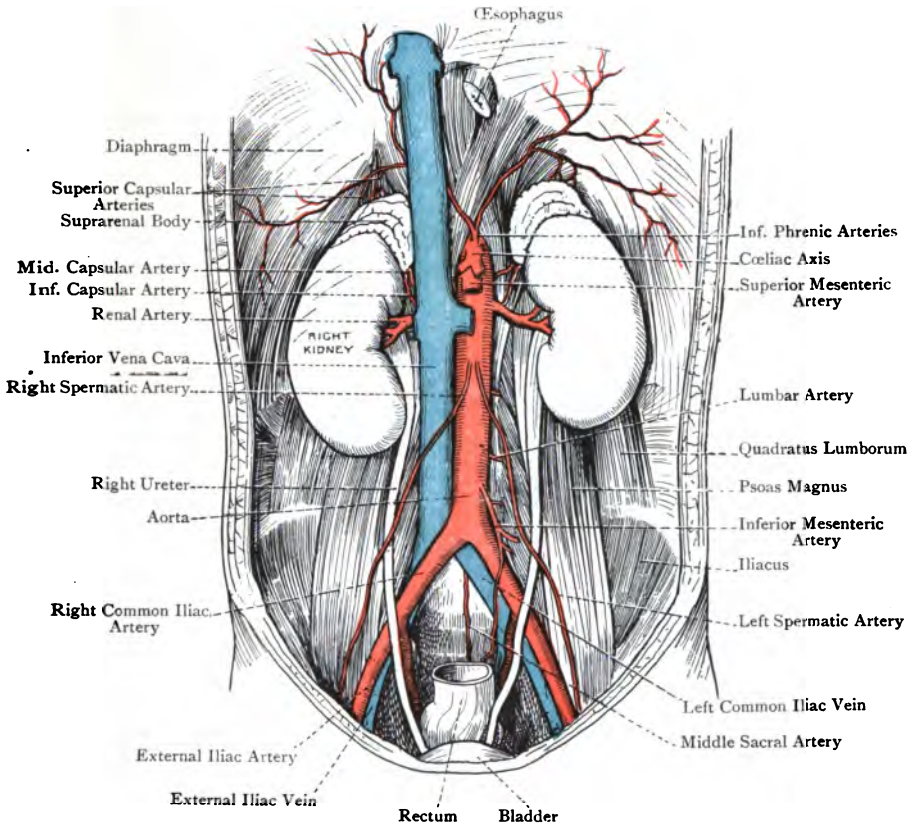


FIG. 312.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

It is covered by peritoneum. The *duodenal area* corresponds with an elongated narrow strip lying close to the hilum, and reaching a little above and below it. It is in contact with the posterior wall of the second part of the duodenum, both being destitute of peritoneum. The *colic area* lies below the hepatic, and, like it, is oblique. It is in contact with the upper end of the ascending colon and the hepatic flexure without the intervention of peritoneum. Between the lower part of the duodenal and the colic impression,

that is, at the lower and inner part of the anterior surface, there is a small area covered by peritoneum which is in contact with a portion of the small intestine.

Anterior Surface of the Left Kidney.—This surface is overlapped by the left suprarenal capsule for a very short distance at its upper and inner part. It presents four visceral areæ—splenic, gastric, pancreatic, and colic. The *splenic area* is situated at the upper and outer part, close to the external border, and is in contact with the renal surface of the spleen, the peritoneum of the great cavity intervening. The *gastric area*, somewhat triangular, lies at the upper end, between the splenic and capsular areæ, and above the pancreatic area. It is in contact with the postero-inferior surface

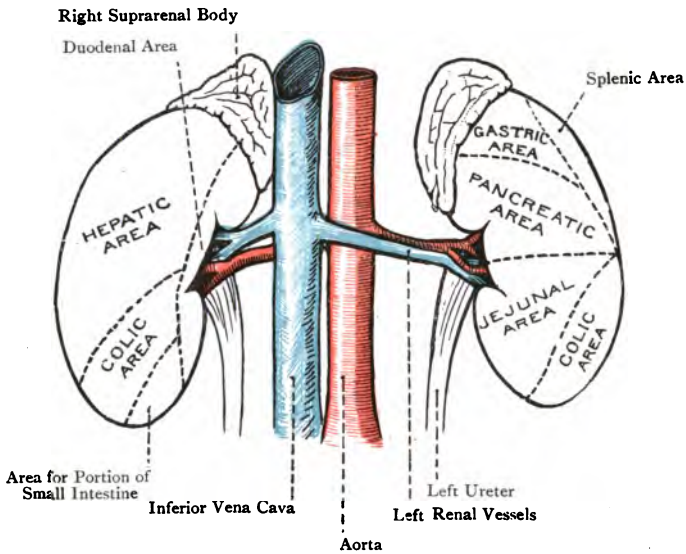


FIG. 313.—THE VISCERAL AREÆ OF THE KIDNEYS
(In this case the right renal vein was higher than usual).

of the stomach with the intervention of the peritoneum of the small sac. The *pancreatic area* lies transversely below the gastric area, and extends as low as about the centre of the hilum. It is in relation with the posterior surface of the body of the pancreas and the splenic vessels, without peritoneum. The *colic area* is situated at the lower and outer part, and is in contact with the splenic flexure and the commencement of the descending colon, without peritoneum. At the lower and inner part there is a small area covered by peritoneum, which is related to a part of the jejunum.

Posterior Surface.—This surface is readily recognised by observing the posterior position of the pelvis of the kidney at the

hilum, with which it coincides. The inner portion of it rests upon (*a*) the psoas magnus and its sheath, and (*b*) the crus of the diaphragm. The outer portion rests, from above downwards, upon (*a*) the twelfth rib (in the case of the left kidney the eleventh rib also), (*b*) the diaphragm, and (*c*) the quadratus lumborum, covered

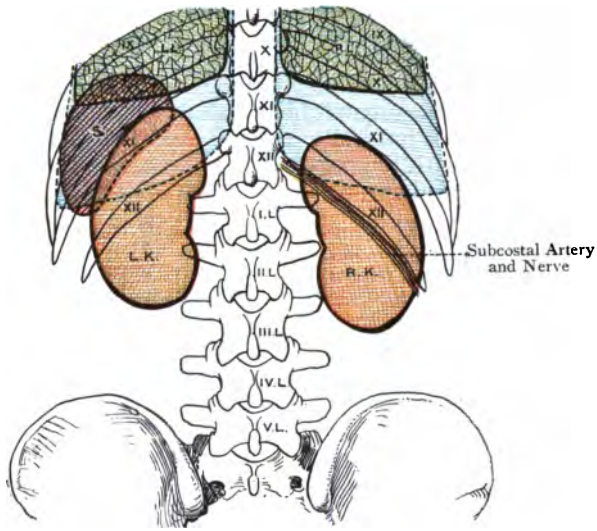


FIG. 314.—DIAGRAM SHOWING THE RELATIONS OF THE KIDNEYS FROM BEHIND.

R.L. Right Lung	XI. Eleventh Rib
L.L. Left Lung	XII. Twelfth Rib
S. Spleen	I.L. First Lumbar Vertebra
R.K. Right Kidney	II.L. Second Lumbar Vertebra
L.K. Left Kidney	III.L. Third Lumbar Vertebra
IX. Ninth Rib	IV.L. Fourth Lumbar Vertebra
X. Tenth Rib	V.L. Fifth Lumbar Vertebra

by the anterior lamina of the lumbar aponeurosis. An important surgical relation of the upper part of this division of the posterior surface is that the pleura, in descending between the diaphragm and the twelfth rib, lies behind the kidney. Three nerves pass downwards and outwards behind the organ, namely, the subcostal, ilio-hypogastric, and inguinal.

The *superior extremity* is capped by the suprarenal capsule, which also extends for a little over the anterior surface and adjacent portion of the internal border.

The *external border*, which is convex, rests on the posterior aponeurosis of the transversalis abdominis. The external border of the right kidney, over about its upper two-thirds, is in contact with the liver, whilst the external border of the left kidney at its upper end is in contact with the spleen.

The *internal border* of the right kidney lies very near the

inferior vena cava, whilst that of the left is situated fully 1 inch from the aorta. This border is concave, and presents a longitudinal fissure, called the *hilum*, which extends over about its middle third. It presents two somewhat thick lips, anterior and posterior, and it leads to a cavity within the organ, called the *sinus*. It transmits the following structures in order from before backwards: the branches of the renal vein, the branches of the renal artery, with branches of the renal sympathetic plexus and lymphatics, and the pelvis of the kidney.

The side to which a kidney belongs may be ascertained in the following way: if the organ is held with that end downwards towards which the ureter is naturally inclined, and that surface backwards which coincides with the pelvis at the hilum, the convex border will then indicate the side to which the organ belongs.

Varieties—Form.—The kidneys may be much elongated, or somewhat round, or triangular. The lobulated condition, which is characteristic of the kidney in early life, may persist in the adult.

Size.—One kidney may be diminished in size, in which cases there is a proportionate increase in the other organ.

Position.—It is very rare to find the kidneys higher than usual, but one or both not infrequently extend into the iliac fossa, or over the pelvic brim.

Number—*Diminution.*—One kidney (usually the left) may be entirely suppressed, in which cases the solitary kidney usually occupies its normal position, and may, or may not, be of large size. *Increase.*—The number may be increased to three, the additional organ being lateral, or median, in position.

Horseshoe Kidney.—This condition is brought about by the fusion of the lower parts of the organs, the connecting band of renal substance extending across the vertebral column.

Preternatural Mobility. — The kidney is usually anchored in its normal position by its capsule and the adjacent viscera, but it is sometimes movable, which may be due to one of two causes: (1) the capsule may be very loose, giving rise to the condition known as **movable kidney**; or (2) the organ may be attached to the posterior abdominal wall by a peritoneal fold, called the *meso-nephron*, in which case the condition known as **floating kidney** occurs, this being said to be more frequent on the right side.

For the structure and development of the kidney, see pp. 766, 777.

Ureter.—The ureter is the excretory duct of the kidney, and it conveys the urine to the bladder. It is a cylindrical, thick-walled tube, like a goose-quill, its average length being about 12 inches, and its diameter about $\frac{1}{5}$ inch. The ureter proper commences towards the lower end of the kidney, where it is the continuation of the pelvis, and it terminates in the bladder. The **pelvis** is funnel-shaped and flattened from before backwards. It lies partly in the sinus, where it receives the calices, and partly outside the hilum, where it lies behind the other transmitted structures. Its direction is downwards and inwards, and, having become narrow, it passes into the ureter proper towards the lower end of the kidney.

The **ureter proper** passes downwards and inwards behind the peritoneum, in contact with the posterior abdominal wall. It rests at first upon the psoas magnus and its sheath, being here crossed superficially by the spermatic (or ovarian) vessels, which

are taking a course downwards and outwards, and deeply by the genito-crural nerve, which is taking a similar course. In this part of its course the right duct has the inferior vena cava near it on its inner side, whilst the left duct has the aorta on its inner side, but at some little distance. The ureter next crosses the terminal part of the common iliac artery (or the commencement of the external iliac), after which it enters the pelvic cavity, the right ureter being crossed by the lower part of the root of the mesentery proper, and the left by a portion of the pelvic meso-colon. In the pelvis the ureter passes downwards and forwards in front of the internal iliac artery to the outer wall of the pelvis, lying beneath the peritoneum, and crossing internally the obturator vessels and nerve, and the obliterated hypogastric artery. It subsequently passes inwards to the bladder, being crossed internally by the vas deferens. Having arrived at the lateral or ureteric angle of the bladder, it commences to pierce the vesical wall anterior to the upper free end of the vesicula seminalis, being here about 2 inches distant from its fellow, and about 1½ inches from the base of the prostate gland. It now pursues an oblique course through the wall of the bladder, lying in it for about ¾ inch, and it finally opens into the interior by a very small slit-like aperture placed obliquely at one angle of the base of the internal trigone, where it is distant from its fellow and from the urethral orifice by about 1¼ inches. In the female the ureter, in its pelvic course, passes along the side of the cervix uteri and upper part of the vagina.

Varieties.—(1) The pelvis may be absent, its place being taken by two, or three, tubes. (2) **Double Ureter.**—The foregoing tubes may remain separate for some distance beyond the hilum, or even as low as the bladder, thus giving rise to a double ureter. A triple ureter is extremely rare. (3) **Dilated Ureter.**—This condition is liable to result in such cases as urethral stricture, enlarged prostate, and vesical calculus.

For the structure of the ureter, see p. 775.

Suprarenal Capsules or **Bodies.**—The suprarenal capsules (adrenals) are two in number, right and left, and are situated in the epigastric region. Each is compressed from before backwards, and broad from side to side. It is set upon the superior extremity of the corresponding kidney, to which it is bound by connective tissue. Each capsule encroaches upon the adjacent parts of the anterior surface and internal border of the kidney, the left being mainly situated upon the internal border. The dimensions of the organ are so variable that they can only be stated approximately as follows: the height is about 1¼ inches, and the breadth rather less than 2 inches. The weight, on an average, is about 2 drachms.

The **right capsule** is rather smaller than the left, and is triangular. It is wedged in between the diaphragm and the posterior surface of the right lobe of the liver, and its surfaces are anterior and posterior, the former having an inclination outwards, and the latter inwards. The *anterior surface*, close to the inner border, is in contact with the inferior vena cava, and elsewhere it is related to the pos-

terior surface of the right lobe of the liver. At its upper and inner part there is a small fissure, called the *hilum*, through which the right suprarenal vein emerges. The peritoneum gives a partial covering to this surface at its lower part. The *posterior surface* is in contact with the diaphragm and the upper part of the anterior surface of the right kidney. The right semilunar ganglion lies on the inner side of the right capsule.

The **left capsule** is somewhat semilunar. The *anterior surface* is related above to the postero-inferior surface of the stomach, with the intervention of the small sac, which furnishes it with a peritoneal covering. Below this it is related to the posterior surface of the body of the pancreas and the splenic vessels, without peritoneum. The hilum, through which the left suprarenal vein emerges, is situated at the lower and inner part of this surface. The *posterior surface* at its upper part is in contact with the left crus of the diaphragm, and, below, it rests upon the upper and inner part of the front of the left kidney, as well as upon its internal border.

For the structure and development of the suprarenal capsule see pp. 765, *et seq.*

Abdominal Aorta.—The abdominal aorta commences at the aortic opening of the diaphragm on a level with the lower border of the body of the twelfth thoracic vertebra, where it lies in the middle line, and it usually terminates opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line, by dividing into the right and left common iliac arteries. The position of the bifurcation may be indicated in one of two ways, as follows: (1) by taking a point fully 1 inch below the umbilicus and a finger's breadth to the left of the linea alba; or (2) by taking a point in the line which connects the highest parts of the iliac crests a finger's breadth to the left of where it intersects the linea alba. The bifurcation may take place a little lower down or higher up than the normal level. The length of the vessel is about 5 inches. It occupies the epigastric and umbilical regions, where it lies very deeply behind the peritoneum, and its direction is downwards with a slight inclination to the left.

Relations—*Anterior.*—The direct anterior relations, from above downwards, are as follows: the origins of the inferior phrenic arteries, the cœliac axis, cœliac glands, and solar plexus, the ascending layer of the transverse meso-colon, the pancreas and splenic vein, the root of the superior mesenteric artery, the third part of the duodenum and left renal vein, the origins of the spermatic (or ovarian) arteries, the aortic plexus, the median group of lumbar glands, the peritoneum of the general cavity, and the origin of the inferior mesenteric artery. The more remote anterior relations are the gastro-hepatic omentum, stomach, transverse colon with its meso-colon, coils of the small intestine, root of the mesentery proper, and gastro-colic omentum. *Posterior.*—The disc between the twelfth thoracic and first lumbar vertebræ, the bodies and discs of the upper four lumbar vertebræ, and

the anterior common ligament, the left lumbar veins, and the origins of the lumbar and middle sacral arteries. *Right.*—The right crus of the diaphragm, with the receptaculum chyli and right vena azygos lying deeply between the vessel and the right crus, the former being nearest the aorta, and slightly covered by it; and the inferior vena cava. *Left.*—The left crus of the diaphragm, the left semi-

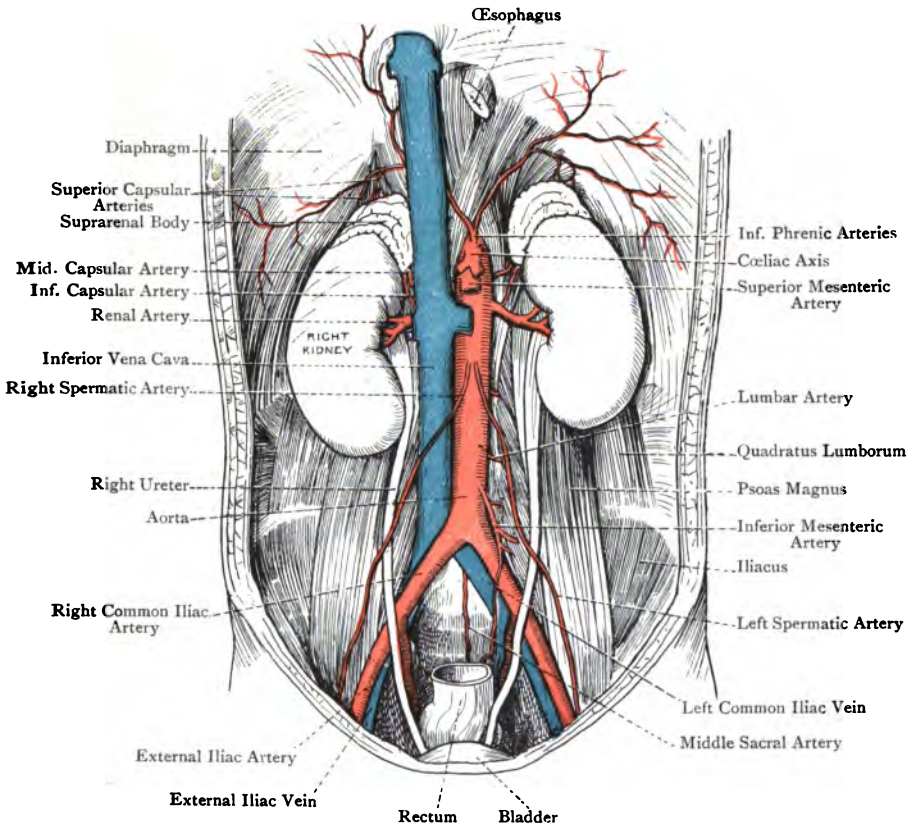


FIG. 315.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

lunar ganglion, the terminal portion of the third part of the duodenum (ascending part of Treves), and the left sympathetic gangliated cord.

Branches.—These are nine in number, and are arranged in two groups, *visceral* and *parietal*, four of them being single, and five arranged in pairs. The four single branches are the cœliac axis, superior mesenteric, inferior mesenteric, and middle sacral. The five pairs are the inferior phrenic, middle capsular, renal, spermatic

(ovarian in the female), and the lumbar. Excluding the lumbar arteries, the order of origin of the branches is as follows: (1) inferior phrenic, (2) cœliac axis, (3) superior mesenteric and (4) middle capsular, both on same level, (5) renal, (6) spermatic (or ovarian), (7) inferior mesenteric, and (8) middle sacral. In what follows the letter P after an artery signifies parietal, and V visceral.

The **inferior phrenic arteries** (P) are two in number, right and left, and they are called *inferior* to distinguish them from the *superior* phrenic of the internal mammary, right and left. They arise, either separately or by a common trunk, from the front of the aorta, whenever the vessel has passed through the aortic opening of the diaphragm. They at once diverge, each passing outwards and upwards over the crus of the diaphragm, the right vessel lying behind the inferior vena cava, and the left behind the œsophagus. Each ends by dividing into two branches, anterior and external. The *anterior branch* passes forwards and inwards in a curved manner in front of the central tendon, and anastomoses with its fellow of the opposite side, and the superior phrenic and musculo-phrenic of the internal mammary. The *external branch* passes outwards, and anastomoses with the musculo-phrenic and the lower intercostal arteries. Each inferior phrenic artery furnishes a *superior capsular branch* (or branches) to the suprarenal capsule, the right vessel also giving off a few branches to the inferior vena cava, whilst the left supplies a few branches to the œsophagus.

The *right* **inferior phrenic vein** opens into the inferior vena cava, and the *left* terminates in the left suprarenal vein, left renal vein, or inferior vena cava.

The **cœliac axis** (V) and **superior mesenteric artery** (V) will be found described on pp. 673, 679.

The **middle capsular arteries** (V) are of small size, and are two in number, right and left, each arising from the side of the aorta on a level with the origin of the superior mesenteric artery. The vessel passes outwards and upwards over the crus of the diaphragm to the suprarenal capsule, in which it anastomoses with the superior capsular of the inferior phrenic and the inferior capsular of the renal.

The *right* **suprarenal vein** opens into the inferior vena cava, and the *left* into the left renal vein.

The suprarenal veins originally open into the cardinal veins. The right suprarenal vein becomes transferred to the upper segment of the inferior vena cava (above the right renal vein). The left suprarenal vein, after the obliteration of the adjacent portion of the left cardinal vein, becomes transferred to the left renal vein.

The **renal arteries** (V) are remarkable for their large size, and are two in number, right and left. They arise from the side of the aorta about $\frac{1}{2}$ inch below the superior mesenteric on a level with the body of the first lumbar vertebra, the right artery being usually a little lower than the left. They form right angles with

the aorta, and cross the crura of the diaphragm on their way to the hila of the kidneys, the right vessel passing behind the inferior vena cava, second part of the duodenum, and head of the pancreas, whilst the left passes behind the body of the pancreas. Each vessel has its own vein in front of it, and the aortico-renal ganglion lies over its root. On approaching the renal hilum each vessel divides into three or four branches, one of which usually passes behind the pelvis of the kidney, whilst the others lie between the renal vein in front and the pelvis behind. For the subsequent distribution of the branches in the kidney, see p. 771.

Before breaking up into its proper renal branches the vessel gives off an *inferior capsular artery* to the suprarenal capsule, *peri-renal branches* to the capsule, and *ureteric* to the upper part of the ureter.

Differences between the Renal Arteries.—(1) The right artery is rather lower than the left. (2) The right is rather longer than the left, on account of the inclination of the aorta to the left of the middle line. (3) The right passes behind the inferior vena cava, second part of the duodenum, and head of the pancreas, whilst the left passes behind the body of the pancreas.

Varieties.—1. Very often there is an *accessory renal artery* present, arising close to the main vessel, and usually above it. 2. The renal artery may divide into its renal branches close to its origin. 3. There may be an *aberrant renal artery*, which may arise from the inferior phrenic, spermatic (or ovarian), inferior mesenteric, common or external iliac, or middle sacral. 4. In cases of variations, or even in the normal condition, one or more of the renal branches may fail to enter the hilum, and may pierce the kidney on its anterior surface, or near the upper or lower end.

The **renal veins,** like the arteries, are of large size. Each lies in front of its artery, and receives tributaries from the adipose tunic and the upper part of the ureter. The vessels are tributaries of the inferior vena cava, which they join almost at a right angle, the left a little higher than the right. The left vein crosses in front of the aorta, taking up in its course the left suprarenal and left spermatic (or ovarian) veins. In some cases there is a single semilunar valve at the lower part of the opening of each renal vein into the inferior vena cava.

Difference between the Renal Veins.—(1) The left vein is longer than the right, on account of the position of the inferior vena cava on the right side. (2) The left is rather higher than the right. (3) The left crosses in front of the aorta. (4) The left receives the left suprarenal and left spermatic (or ovarian) veins.

The renal veins originally open into the cardinal veins. Subsequently the right renal vein opens into the junction of the upper and lower segments of the inferior vena cava. When the left cardinal vein becomes obliterated, in great part the left renal vein becomes continuous with the left division of the primitive inferior vena cava. The mesial portion of the left renal vein is developed from the left division of the primitive inferior vena cava.

The **spermatic arteries** (V) are two in number, right and left, and they arise from the front of the aorta about 1 inch below the renal arteries. If they arise separately they are close to each other, but they sometimes spring by a common trunk. They are long, slender, somewhat tortuous vessels, which at once diverge, each passing obliquely downwards and outwards behind the peritoneum. In this course the vessel rests upon the aorta for a short distance, and then upon the psoas magnus and its sheath, where it crosses the ureter. The right artery passes in front of the inferior vena cava and behind the terminal part of the ileum, whilst the left passes behind the iliac colon. Subsequently the artery, on its way to the internal abdominal ring, lies upon the terminal part of the external iliac. At the internal ring it is joined by the vas deferens to form, with other structures, the spermatic cord. The vessel then passes through the internal abdominal ring, along the inguinal canal, and through the external abdominal ring into the scrotum, where it divides into testicular and epididymal branches. In the abdomen the spermatic artery furnishes ureteric branches to the ureter, and in the scrotum it gives off cremasteric branches to the coverings of the spermatic cord, which anastomose with the cremasteric branch of the deep epigastric. During fœtal life the vessel is very short, and takes a transverse course to the testis, which is then lying below and behind the kidney. As the testis, however, descends into the scrotum the vessel gradually becomes much elongated.

Varieties.—(1) One or both spermatic arteries may be absent, in which cases the testis is supplied chiefly by the deferential artery. (2) A spermatic artery may arise from a renal artery.

The **spermatic veins** spring from the pampiniform plexus of the spermatic cord at the internal abdominal ring, and are at first two in number on each side, which lie one on either side of the corresponding artery. They subsequently unite to form a single vessel, which on the *right* side opens at an acute angle into the inferior vena cava, and on the *left* at a right angle into the left renal vein. There is usually a valve at the point of termination of each vein, though this may be absent. In the left spermatic vein, where it joins the left renal vein, the valve directs the current of blood entering by the spermatic vein in the direction of the inferior vena cava. It also prevents the blood in the left renal vein from entering the spermatic vein by directing the current over the mouth of the latter vessel. The *left* spermatic vein is rather longer than the right.

The spermatic veins originally open into the cardinal veins. The *right* spermatic vein opens into that portion of the right cardinal vein which persists as the lower segment of the permanent inferior vena cava. The upper part of the *left* spermatic vein is formed from that portion of the left cardinal vein which lies immediately below the left renal vein. In this manner the difference in the mode of termination of the two spermatic veins in the adult is accounted for.

The **ovarian arteries** (V), in the female, take the place of the spermatic arteries in the male, and their course and relations in the abdomen correspond with those of the spermatics. The ovarian arteries are, however, shorter than the spermatics, and they do not pass out through the inguinal canal, but enter the pelvis by crossing the commencement of the external iliac artery. In the pelvis each vessel becomes very tortuous, and passes between the two layers of the broad ligament of the uterus to be distributed to the ovary. In the abdomen the artery supplies branches to the ureter, and in the pelvis it furnishes the following offsets : *tubal* to the Fallopian tube ; a *uterine branch* to the side of the uterus ; and a *ligamentous branch* to the round ligament of the uterus, which it accompanies as far as the inguinal canal. The ovarian arteries, like the spermatic, are very short and transverse in direction during fœtal life, when the ovary occupies a position similar to that of the testis. They, however, gradually become elongated as the ovary descends to its future abode in the pelvis.

The **ovarian veins** spring from the ovarian or pampiniform plexus between the two layers of the broad ligament, close to the ovary. After emerging therefrom their subsequent course and mode of termination resemble those of the spermatic veins.

For the **inferior mesenteric artery** (V) and **vein,** see p. 684 ; for the **middle sacral artery** (P) and **vein,** see p. 806 ; and for the **lumbar arteries** (P) and **veins,** see p. 725.

Inferior Vena Cava.—The inferior vena cava commences opposite the upper border of the body of the fifth lumbar vertebra a little to the right of the middle line, where it is formed by the union of the right and left common iliac veins, and it terminates at the postero-inferior angle of the right auricle of the heart. It ascends along the right side of the aorta, resting upon the anterior and right aspects of the lumbar vertebræ as high as the level of the second. Beyond this point it diverges from the aorta, and is supported by the right crus of the diaphragm. It then occupies the caval fossa on the posterior surface of the right lobe of the liver. On leaving this fossa it passes through the caval opening in the central tendon of the diaphragm, and, almost immediately thereafter, it opens into the postero-inferior angle of the right auricle of the heart. As the vein passes through the caval opening its walls are connected with the margins of that opening, and so the patency of the vessel is maintained.

Relations—*Anterior.*—From below upwards, the right common iliac artery, lower part of the root of the mesentery proper, right spermatic (or ovarian) vessels, third part of the duodenum, head of the pancreas, origin of the vena portæ, first part of the duodenum, foramen of Winslow, and posterior surface of the liver. *Posterior.*—The bodies, discs, and anterior common ligament of the lower three lumbar vertebræ, the corresponding right lumbar vessels, inner border of the right psoas magnus and its sheath,

right sympathetic gangliated chain, right renal artery, right semilunar ganglion, right crus of the diaphragm, right suprarenal capsule, and right inferior phrenic artery. *Right.*—From below upwards, the right ureter and the internal border of the right kidney.

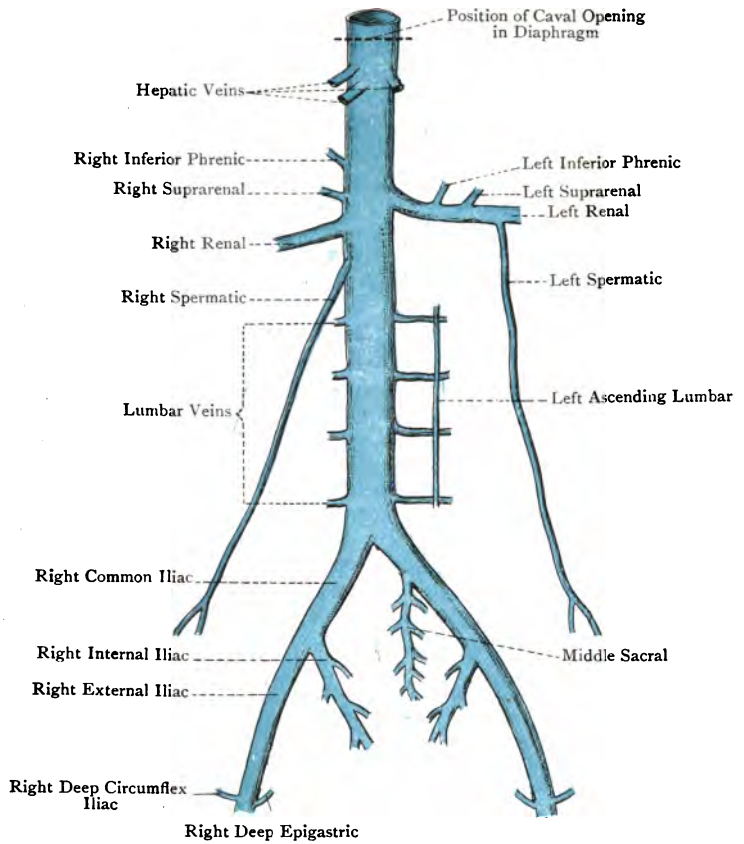


FIG. 316.—SCHEME OF THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.

Left.—From below upwards, the aorta and the right crus of the diaphragm.

Tributaries.—These are as follows: the right and left common iliac veins, right and left lumbar veins, the right spermatic (or ovarian) vein, the right and left renal veins, the right suprarenal vein, the right inferior phrenic vein (and sometimes the left), and the hepatic veins at the caval fossa of the liver.

Chief Varieties.—(1) The vessel may be found on the left side of the aorta in its lower part, in which cases it subsequently crosses that vessel to take up

its usual position on its right side. This may be due to a transposition of viscera, or to a permanent patency of the lower part of the left cardinal vein of fœtal life. (2) The inferior vena cava, in very rare cases, may terminate in a large right azygos vein, and, through means of that, in the superior vena cava. Under these circumstances the hepatic veins open into the right auricle of the heart.

Development. — The *upper segment* is developed from the primitive inferior vena cava and its right division. The *lower segment* is developed from the portion of the right cardinal vein which lies between the right extremity of the primitive transverse iliac vein and the right renal vein.

Diaphragm—*Origin*—**Sternal Portion.**—By two fleshy slips from the back of the ensiform process close to its lower end. **Costal Portion.**—By six fleshy slips, at either side, from the inner surfaces of the lower six costal cartilages, which interdigitate with slips of the transversalis abdominis. **Vertebral Portion.**—From the external and internal arcuate ligaments, and the fronts of the bodies of lumbar vertebræ, as well as the intervertebral discs and anterior common ligament, by two crura, the right crus reaching usually as low as the disc between the third and fourth lumbar bodies, and the left as low as the disc between the second and third.

Insertion.—The central tendon on all sides.

Nerve-supply.—The right and left phrenic nerves, each of which springs chiefly from the anterior primary division of the fourth cervical nerve, and usually receives a branch from the third, and sometimes from the fifth. Each phrenic nerve, on approaching the diaphragm, divides into branches which pierce its muscular part separately in front of the central tendon, and are distributed on the abdominal surface of the muscle. In the right half of the muscle a communication takes place between the right phrenic nerve and the right inferior phrenic sympathetic plexus, a small ganglion, called the *ganglion diaphragmaticum*, being situated at the place of communication. A similar connection is established on the left side, but no ganglion is present.

Arterial Supply. — (1) The inferior phrenic branches of the abdominal aorta ; (2) the superior phrenic (comes nervi phrenici) and musculo-phrenic, both branches of the internal mammary of each side ; (3) the phrenic branch of the superior epigastric of the internal mammary of each side ; and (4) branches from the lower intercostal arteries.

Lymphatics.—These pass to the sternal, anterior mediastinal, posterior mediastinal, intercostal, and lumbar glands.

Action.—The diaphragm by its contraction increases the vertical diameter of each half of the thorax, and is therefore a muscle of inspiration. The middle portion of the central tendon is fixed by reason of the fibrous portion of the pericardium, which is implanted into it, being connected above with the deep cervical fascia. The fleshy portion, however, becomes flattened, and descends towards the abdomen, displacing the viscera, and so increasing the vertical

diameter of each half of the thorax. The diaphragm also elevates the lower ribs, except the last.

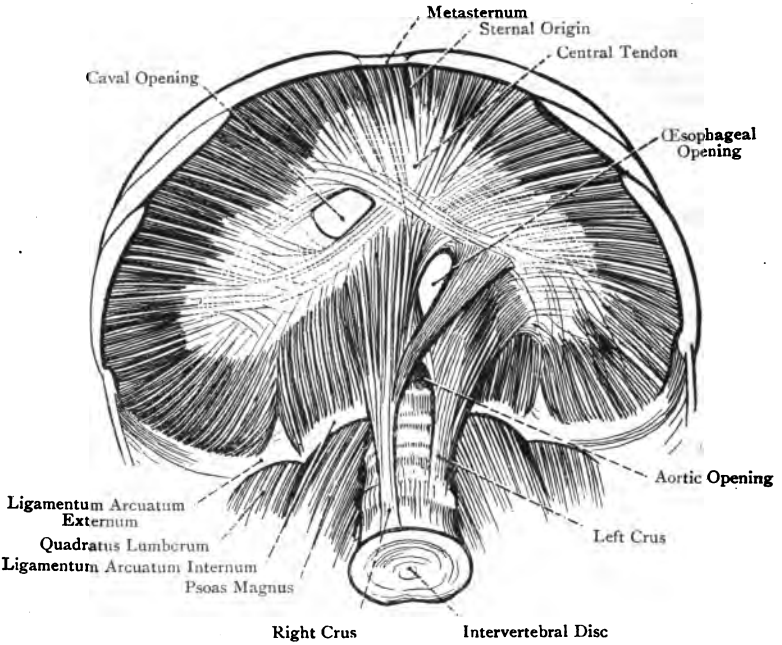


FIG. 317.—THE DIAPHRAGM (INFERIOR VIEW).

The muscular fibres pass in an arched manner upwards and inwards to the central tendon, upon which they converge from all points. The sternal portion is separated on either side from the costal portion by a small interval occupied by areolar tissue, through which the superior epigastric vessels and some of the superficial lymphatics of the upper surface of the liver pass. Above and below this interval are the pleura and peritoneum respectively. In this situation a diaphragmatic hernia may take place, involving one or other of the abdominal viscera. Between the lowest costal fibres and the corresponding external arcuate ligament there is sometimes another areolar interval of small size. The **crura** are strong, thick musculo-tendinous bundles disposed vertically, the left being the smaller, shorter, and more posterior of the two. Each crus is fleshy externally, and strongly tendinous internally, the lower extremity of each being entirely tendinous. On a level with the lower border of the body of the twelfth thoracic vertebra the inner tendinous fibres of the crura are connected by a fibrous band, called the middle arcuate ligament, which lies in front of the aorta. The muscular fibres of the crura pass upwards in a diverging manner to be inserted into the posterior border of the central tendon. The innermost muscular fibres on either side, reinforced by fibres springing from the middle arcuate ligament, decussate before reaching the central tendon and enclose between them the œsophageal opening. In the decussation the bundle derived from the right crus passes in front of that from the left, which latter is of small size.

The **central tendon** is also called the *cordiform* or *trefoil* tendon. It is much elongated from side to side, convex in front, and con-

cave behind. It is divided into three lobes or alæ, right, middle, and left, of which the right is the largest, and the left the smallest and narrowest. The separation into lobes is indicated by two small notches situated in the course of the anterior convex border.

The diaphragm presents three foramina, namely, aortic, caval, and œsophageal.

The **aortic opening** is situated in the middle line between the upper portions of the crura, and in front of the disc between the bodies of the twelfth thoracic and first lumbar vertebræ. It is bounded on either side by a crus, in front by the middle arcuate ligament, and behind by the anterior common ligament of the

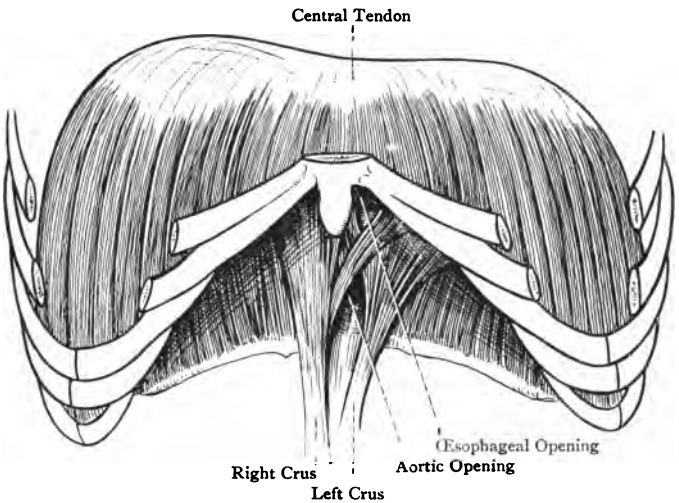


FIG. 318.—THE DIAPHRAGM (SUPERIOR VIEW)

(After L. Testut's "Anatomie Humaine").

vertebral column. It is therefore not really an opening in the diaphragm, but is situated behind it. It transmits the aorta, thoracic duct, and right azygos vein, in this order from left to right.

The **caval opening** (*foramen quadratum*) is situated in the central tendon close to its posterior border, and at the junction of the right and middle lobes. It is somewhat four-sided with rounded angles, and transmits the inferior vena cava and some of the deep lymphatics of the liver.

The **œsophageal opening** is situated in the fleshy part of the muscle. It is elliptical, and lies in front, and a little to the left, of the aortic opening, being separated from it behind by the inner decussating fibres of the crura. It transmits the œsophagus, the

right and left pneumogastric nerves, and the œsophageal branches of the gastric artery.

In addition to the foregoing foramina, the diaphragm presents certain small fissures, as follows: each crus is pierced by the great and small splanchnic nerves, and sometimes by the least. The left crus is also pierced by the lower left azygos vein. The musculo-phrenic artery pierces the costal portion, and the branches of the phrenic nerve are also transmitted through the muscle.

The **arcuate ligaments** are five in number, as follows: external, right and left; internal, right and left; and middle. The **external arcuate ligament** is a thickening of the upper part of the anterior wall of the sheath of the quadratus lumborum, and extends from the last rib to the tip of the transverse process of the first lumbar vertebra. The subcostal artery and nerve pass downwards and outwards behind it. The **internal arcuate ligament** is a thickening of the upper part of the sheath of the psoas magnus, and extends from the tip of the transverse process of the first lumbar vertebra to the side of its body. The gangliated cord of the sympathetic passes into the abdomen behind it, and sometimes the least splanchnic nerve. The **middle arcuate ligament** is a fibrous band which connects the innermost tendinous fibres of the crura on a level with the lower border of the body of the twelfth thoracic vertebra, and it arches over the aorta.

Relations of the Diaphragm—*Superior.*—The right and left pleuræ with the lungs, and the pericardium with the heart. *Inferior.*—The peritoneum, except opposite the uncovered area of the posterior surface of the liver; the liver with its suspensory, coronary, and right and left lateral or triangular ligaments; the stomach; spleen; pancreas; kidneys; and suprarenal capsules.

Development.—The diaphragm is of mesoblastic origin, and is developed in two parts, ventral and dorsal. The *ventral part*, which is the first to appear, is developed from the upper stratum of the *septum transversum* of His, and it ends posteriorly in a free projecting edge. It shuts off a considerable part of the thorax from the abdomen, leaving two spaces, one on each side of the primitive alimentary tube, which are destined to form the pleural cavities. The *dorsal part* consists of two divisions, which grow inwards and forwards from the lateral and posterior walls of the embryo, and fuse with the posterior free edge of the ventral part, thus completing the diaphragm. This fusion however, may be incomplete, in which cases a free communication is left between the thoracic and abdominal cavities, through which a diaphragmatic hernia may occur.

Gangliated Cord of the Sympathetic.—This cord enters the abdomen behind the inner portion of the internal arcuate ligament. It then descends along the inner border of the psoas magnus, where it lies *in front of* the bodies of the lumbar vertebræ, and, having passed behind the common iliac artery, it enters the pelvis. The right lumbar cord is under cover of the inferior vena cava, whilst the left lies a little to the left of the aorta, and the lumbar vessels of each side pass beneath the corresponding cord. Each cord usually contains four ganglia.

Branches.—These are arranged in two sets, namely, rami communicantes, and branches of distribution. The *rami communicantes*, which are long, are of two kinds, white and grey, the latter being

the more numerous. The *white* rami are composed of medullated nerve-fibres, and are not more than three in number. They are derived from the anterior primary divisions of the first three lumbar nerves, and proceed to the ganglia. The *grey* rami pass from all four ganglia to join the anterior primary divisions of the five lumbar nerves. Both white and grey rami pass together beneath the fibrous arches of the psoas magnus in company with the lumbar vessels, and the communications with the lumbar nerves are established close to the intervertebral foramina. The *branches of distribution* proceed partly from the ganglia and partly from the connecting cord, and are distributed to the coats of the aorta, the bodies and ligaments of the lumbar vertebræ, and the hypogastric plexus, the last branches crossing the common iliac artery.

Receptaculum Chyli.—This is the dilated commencement of the thoracic duct. It is situated deeply at the upper part of the posterior abdominal wall in front of the bodies of the first and second lumbar vertebræ, where it has the aorta on its left side and slightly in front, and the right azygos vein on its right side. It is overlapped by the right crus of the diaphragm. It is somewhat elliptical, being about $\frac{1}{6}$ inch broad at its widest part, and about 2 inches in length. Superiorly it becomes narrow, and is continued into the thoracic duct, which enters the thorax through the aortic opening of the diaphragm. It receives the following afferent vessels from below upwards: the right and left lumbar lymphatic trunks from the median lumbar glands, which join its lower narrow end; some of the efferent vessels from the lateral lumbar glands; and the intestinal lymphatic trunk (or trunks) from the mesenteric glands, which sometimes takes up the efferent vessels of the cœliac glands, though these may enter the receptaculum chyli independently.

Azygos Veins.—These are three in number, namely, the vena azygos major, or right azygos vein, the vena azygos minor or lower left azygos vein, and the upper left, or accessory, azygos vein.

The **vena azygos major** or **right azygos vein** usually commences in the *right ascending lumbar vein*, which is formed by longitudinal anastomosing branches passing between the lumbar veins in front of the lumbar transverse processes, and so disposed as to form one vein which communicates with the inferior vena cava and with one or other of the following veins of the right side: the common iliac, the internal iliac, the ilio-lumbar, or the lateral sacral. Sometimes, however, the right azygos vein springs from the posterior aspect of the inferior vena cava close to the right renal vein, or from that renal vein itself, or from the first right lumbar vein. It ascends upon the body of the first lumbar vertebra, where it lies on the right side of the receptaculum chyli under cover of the right crus of the diaphragm, and it enters the thorax through the aortic opening of that muscle. For its subsequent course in the thorax, where it terminates in the superior vena cava, see the section of the thorax.

The **vena azygos minor** or **lower left azygos vein** commences in

the *left ascending lumbar vein*, through which it has communications similar to those of the right azygos vein. It may, however, spring from the left renal vein, or the first left lumbar vein. It enters

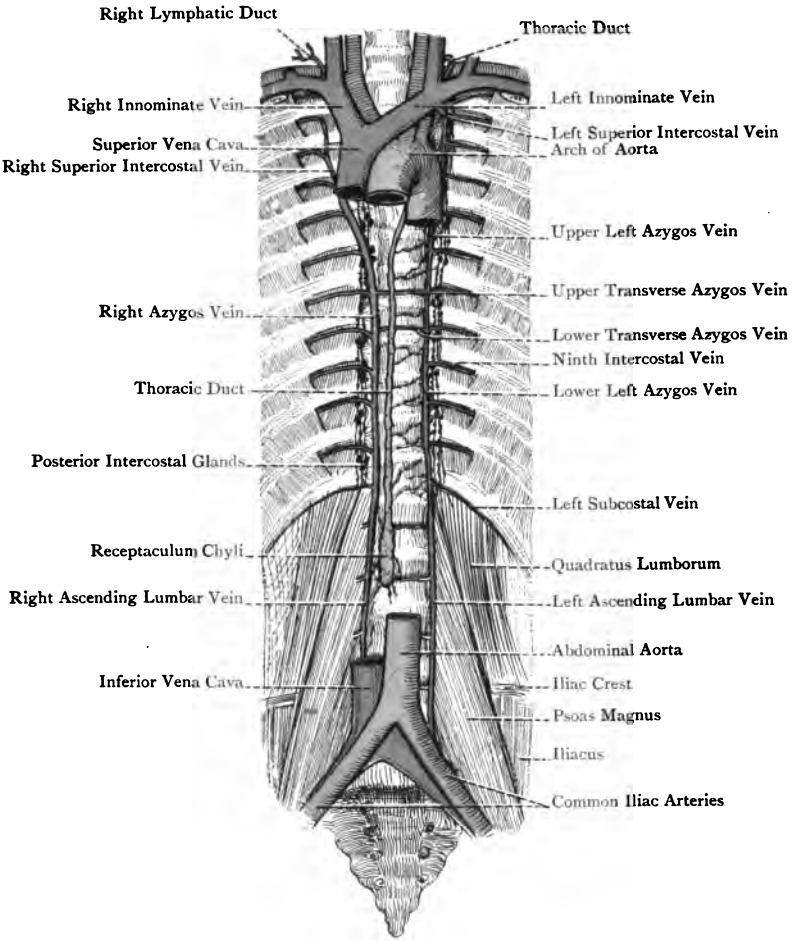


FIG. 319.—THE THORACIC DUCT, AZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

the thorax through the left crus of the diaphragm, and subsequently terminates in the right azygos vein.

The right and lower left azygos veins are persistent portions of the right and left cardinal veins of fœtal life.

The right and lower left azygos veins, through their connections with the ascending lumbar veins, establish communications with

the inferior vena cava, and with the common iliac veins or some of their tributaries. They therefore form important channels by which a considerable quantity of blood is returned from the lower limbs and abdominal wall in cases of obstruction of the inferior vena cava.

The upper left, or accessory, azygos vein will be found described in connection with the thorax.

Fasciæ of the Posterior Abdominal Wall—Iliac Fascia.—This fascia covers the iliacus and psoas magnus muscles. Above the level of the iliac crest it is related only to the psoas magnus, and the part covering that muscle is spoken of as the *psoas sheath*. *Superiorly* it forms the internal arcuate ligament, which extends between the tip of the first lumbar transverse process and the side of the body of that vertebra. *Internally* it is attached to (*a*) the intervertebral discs and contiguous margins of the bodies of the lumbar vertebræ, and (*b*) the fibrous arches over the lumbar vessels opposite the centre of each lumbar body. *Externally*, near the tips of the lumbar transverse processes, it blends with the anterior lamina of the lumbar aponeurosis which covers the quadratus lumborum. Below the level of the iliac crest the iliac fascia covers the iliacus as well as the psoas magnus. This part of it is known as the *fascia iliaca*, and it passes uninterruptedly from the iliacus on to the psoas magnus. *Externally* it is attached to the anterior two-thirds of the iliac crest immediately within its inner lip, and *internally* to the ala of the sacrum and the iliac portion of the ilio-pectineal line. *Inferiorly* it is disposed in the following manner : along the outer half of Poupart's ligament on its deep aspect the fascia is firmly attached to that ligament, and joins the fascia transversalis, the two constructing a canal which contains the first part of the deep circumflex iliac artery. Opposite the external iliac vessels the fascia passes downwards behind them and Poupart's ligament to form the posterior wall of the crural sheath. Internal to the external iliac vessels it is continuous with the pubic lamina of the fascia lata, as that covers the upper part of the pectineus. From the point of junction between the iliac fascia and the pubic fascia lata an intermuscular septum (ilio-pectineal) passes backwards between the pectineus and the psoas magnus to be attached to the ilio-pectineal eminence and the front of the capsular ligament of the hip-joint.

The importance of the iliac fascia has reference to the course taken by pus in cases of lumbar (psoas) abscess. The pus cannot pass outwards over the quadratus lumborum without bursting through the psoas sheath, because the psoas sheath is bound down to the anterior wall of the sheath of the quadratus lumborum at the outer border of the psoas muscle. It cannot pass across the vertebral column on account of the attachments of the psoas sheath in that situation. The usual course, therefore, taken by the pus is to diffuse itself downwards within the psoas sheath. On reaching the iliac fossa it may diffuse itself outwards beneath the iliac fascia as that covers the iliacus muscle, but it cannot enter the pelvic cavity on account of the attachment of the iliac fascia to the pelvic brim, unless it bursts through the psoas sheath. Subsequently the pus usually treks along the psoas magnus

within its sheath, and, passing behind Poupart's ligament and the femoral vessels encased in the crural sheath, it usually points over the saphenous opening on a level with the small trochanter, where it may simulate a femoral hernia.

Lumbar Aponeurosis.—This is situated between the last rib and the iliac crest, and is to be regarded as the posterior aponeurosis of the transversalis abdominis muscle. When followed backwards it divides into three laminæ, anterior, middle, and posterior. The **anterior lamina,** which is thin, covers the quadratus lumborum, and is attached internally to the fronts of the transverse processes of the lumbar vertebræ near their tips. In this situation it is interposed between the quadratus lumborum and psoas magnus, and receives the iliac fascia which forms the psoas sheath. At the outer

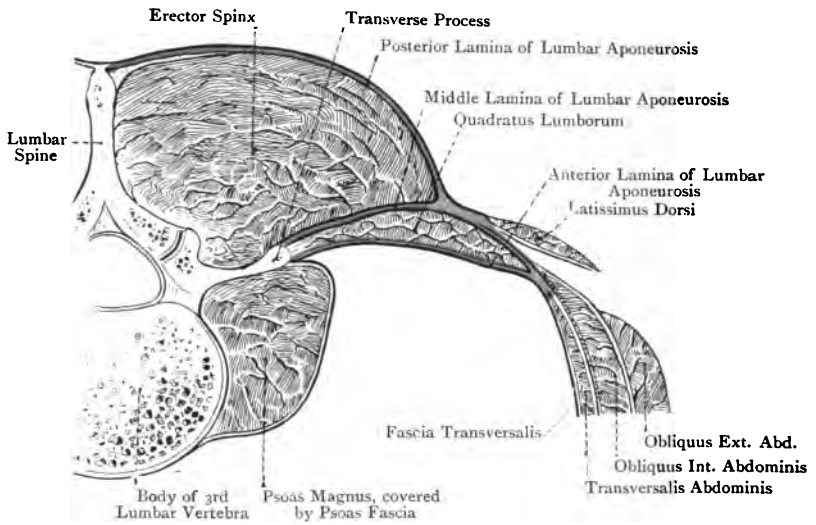


FIG. 320.—DIAGRAM OF THE LUMBAR APONEUROSIS.

border of the quadratus lumborum it joins the middle lamina, and is here also continuous with the fascia transversalis. Superiorly it forms the external arcuate ligament, which extends between the last rib and the tip of the first lumbar transverse process. Inferiorly it is attached to the ilio-lumbar ligament and the contiguous part of the inner lip of the iliac crest. The **middle lamina,** which is of considerable strength, is attached internally to the tips of the lumbar transverse processes, and externally, at the outer border of the quadratus lumborum, it is joined by the anterior lamina, whilst at the outer border of the erector spinæ it receives the posterior lamina. Superiorly it is attached to the lower border of the last rib, and inferiorly to the back part of the summit of the iliac crest. The middle lamina lies between the quadratus lumborum and the

erector spinæ. The **posterior lamina,** which is also very strong, is attached to the spinous processes of the lumbar and sacral vertebræ, and the posterior fourth of the outer lip of the iliac crest. It lies behind the erector spinæ, at the outer border of which it blends with the middle lamina, and so the muscle is enclosed in a sheath. The posterior lamina is joined by the vertebral aponeurosis, and affords attachment to the latissimus dorsi and serratus posticus inferior.

Muscles of the Posterior Abdominal Wall—Psoas Magnus—*Origin.*—(1) The fronts of the transverse processes of the lumbar vertebræ; (2) the lateral aspects of the intervertebral discs, and of the adjacent borders of the twelfth thoracic, and all the lumbar, vertebræ; and (3) a series of fibrous arches which cross the lumbar vessels at the centres of the bodies of the lumbar vertebræ.

Insertion.—The small trochanter of the femur, by a tendon which receives, on its outer side, the greater part of the iliacus.

Nerve-supply.—The lumbar plexus. The branches come more particularly from the anterior primary divisions of the second and third lumbar nerves.

Action.—Acting from its origin the muscle is a powerful flexor of the thigh upon the pelvis, coming into play in walking, or ascending a stair. Acting from its insertion it is a flexor of the lumbar portion of the vertebral column upon the pelvis, and of the pelvis upon the thigh, as in the act of stooping. The muscle of one side, acting from its insertion, is capable of producing lateral flexion of the lumbar portion of the vertebral column.

As the muscle descends close to the pelvic brim the fibres of the iliacus begin to join the outer side of its tendon, and they continue to do so as far as the insertion, thus giving rise to a conjoined muscle known as the **ilio-psoas.**

Psoas Parvus.—This muscle is present in man on one or both sides in about 45 per cent. of bodies. It *arises* from the lateral aspect of the intervertebral disc between the twelfth thoracic and first lumbar vertebræ, and from the contiguous borders of their bodies, by means of a small fleshy belly, which is usually about 2 inches long. It is then replaced by a long, narrow, flat tendon, which expands as it is about to take *insertion* into the middle of the ilio-pectineal line and the ilio-pectineal eminence, in which latter situation it blends with the ilio-pectineal intermuscular septum.

The *nerve-supply* is the anterior primary division of the first lumbar nerve. Acting from its origin the muscle tends to flex the pelvis upon the vertebral column, and is a tensor of the psoas sheath. Acting from its insertion it tends to flex the lumbar portion, and lower part of the thoracic portion, of the vertebral column upon the pelvis. Its characteristic action is seen in the position assumed by saltatory animals preparatory to the act of leaping, that position consisting in a drawing forwards of the pelvis and vertebral column.

The psoas parvus lies along the anterior aspect of the psoas magnus close to its inner border, except at the pelvic brim, where its expanded tendon turns to the inner side of that muscle.

Iliacus—*Origin.*—(1) The upper surface of the ala of the sacrum; (2) the anterior sacro-iliac, ilio-lumbar, and lumbo-sacral ligaments; and (3) the upper half of the iliac fossa, reaching anteriorly as low as the anterior inferior iliac spine.

Insertion.—(1) The outer aspect of the tendon of the psoas magnus; (2) the triangular surface which is situated below, and in front of, the small trochanter of the femur (between it and the spiral line); and (3) the ilio-femoral ligament. The fibres inserted into the ilio-femoral ligament are those which arise in the region of the anterior inferior iliac spine. They are sometimes separated from the rest of the muscle, and are then known as the *iliacus minor* or *ilio-capsularis.*

Nerve-supply.—The anterior crural nerve.

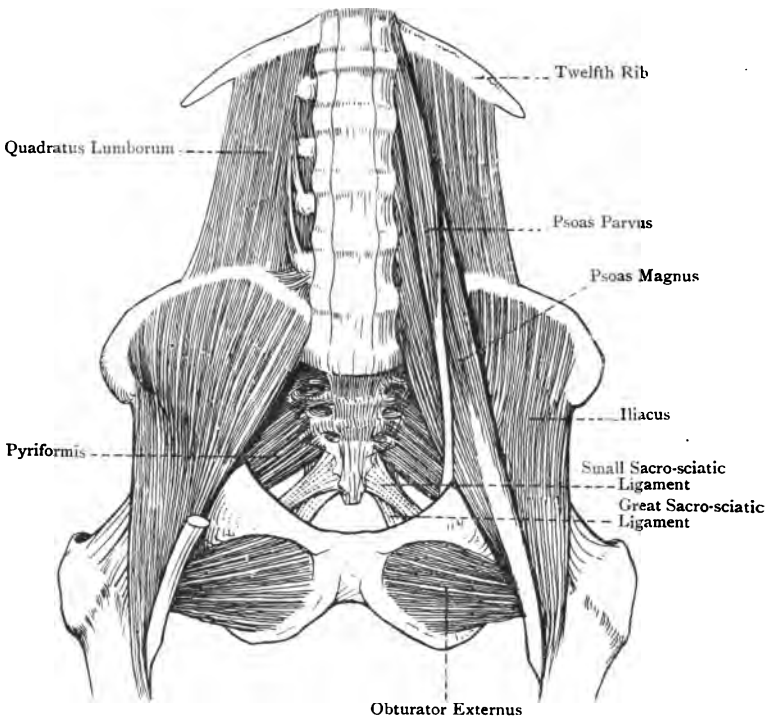


FIG. 321.—THE PSOAS, ILIACUS, AND QUADRATUS LUMBORUM MUSCLES.

Action.—Acting from its origin the muscle is a flexor of the thigh upon the pelvis. Acting from its insertion it is a flexor of the pelvis upon the thigh.

Quadratus Lumborum—*Origin.*—(1) The ilio-lumbar ligament; (2) the inner lip of the crest of the ilium for about 2 inches behind and outside the ilio-lumbar ligament; and (3) the tips of the transverse processes of the lower three or four lumbar vertebræ.

Insertion.—(1) The lower border of the last rib along its inner half, and (2) the tips of the transverse processes of the upper three or

four lumbar vertebræ, by tendinous slips which lie behind the slips of origin.

Nerve-supply.—The subcostal nerve and the anterior primary divisions of the first two lumbar nerves.

Action.—Acting from its origin the muscle depresses and fixes the last rib, and is therefore a muscle of inspiration, inasmuch as it is auxiliary to the diaphragm. In depressing the last rib the muscle is also capable of producing lateral flexion of the vertebral column. Acting from the last rib it will produce lateral flexion of the pelvis.

The muscle is encased in a sheath, the anterior wall of which is formed by the anterior lamina of the lumbar aponeurosis, and the posterior wall by the middle lamina.

Lumbar Plexus.—The lumbar plexus is situated deeply in front of the transverse processes of the first three lumbar vertebræ, where it lies in the psoas magnus. It is formed by the anterior primary divisions of the first three lumbar nerves and the greater part of that of the fourth. In addition, the anterior primary division of the first lumbar is usually reinforced by a small communicating branch from the subcostal nerve, called the *dorso-lumbar nerve.* The nerves concerned in the lumbar plexus first furnish the following branches: (1) the first gives twigs to the psoas parvus when present; (2) the first and second supply branches to the quadratus lumborum; (3) the second and third give branches to the psoas magnus; and (4) the upper two or three furnish white rami communicantes to the lumbar sympathetic gangliated cord. The mode of formation and branches of the plexus are as follows: The first lumbar, having been, as a rule, reinforced by the dorso-lumbar from the subcostal, furnishes, from above downwards, the ilio-hypogastric and inguinal, and then it descends to join a branch from the second. The second, third, and that part of the fourth which enters into the plexus break up into a small anterior or ventral, and a large posterior or dorsal division. The descending branch from the first joins a branch from the ventral division of the second to form the genito-crural nerve, which arises next in order to the inguinal. The external cutaneous nerve arises by two roots from the dorsal divisions of the second and third. The anterior crural nerve arises by three roots from the dorsal divisions of the second, third, and fourth, the root from the third being the largest. The obturator nerve arises usually by three roots from the ventral divisions of the second, third, and fourth, but the root from the second may be absent. The accessory obturator nerve, when present, arises by two roots from the third and fourth, which are interposed between the roots of the anterior crural and main obturator nerves.

The branches of the lumbar plexus are accordingly as follows:

1. Muscular to psoas parvus (when present), from first lumbar.
2. Muscular to quadratus lumborum, from first and second lumbar.

3. Muscular to psoas magnus, from second and third lumbar.
4. Two or three white rami communicantes, to the lumbar sympathetic gangliated cord, from the upper two or three lumbar.
5. Ilio-hypogastric and inguinal, from first lumbar.
6. Genito-crural, from first and *ventral* division of second lumbar.
7. External cutaneous, from *dorsal* divisions of second and third lumbar.
8. Anterior crural, from *dorsal* divisions of second, third, and fourth lumbar.
9. Obturator, from *ventral* divisions of second, third, and fourth lumbar.
10. Accessory obturator (when present), from third and fourth lumbar, between the roots of the anterior crural and main obturator.

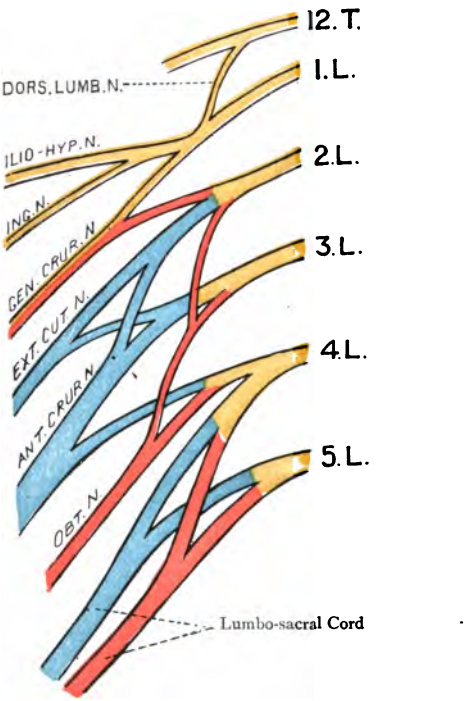


FIG. 322.—DIAGRAM OF THE RIGHT LUMBAR PLEXUS.

The **ilio-hypogastric nerve**, having pierced the outer border of the psoas magnus near its upper part, passes outwards and downwards over the quadratus lumborum, lying below the subcostal nerve and behind the kidney. It then pierces the posterior part of the transversalis abdominis a little above the iliac crest, and furnishes its *iliac* or *lateral cutaneous branch*, which, perforating

the internal and external oblique, crosses the iliac crest at the junction of its middle and anterior thirds to be distributed to the integument of the adjacent part of the gluteal region. The nerve continues its course forwards between the internal oblique and transversalis abdominis, supplying branches to these muscles and communicating with the inguinal nerve. About 1 inch in front of the anterior superior iliac spine it pierces the internal oblique, and then runs forwards between the Poupart fibres of that muscle and the external oblique aponeurosis. Finally it pierces that aponeurosis 1 inch above the external abdominal ring, and is distributed to the integument of the suprapubic region, where it is in series with the anterior cutaneous nerves. The ilio-hypogastric nerve is serially continuous with the intercostal nerves, like which it gives off a lateral cutaneous branch, called iliac, and then ends as an anterior cutaneous nerve.

The **inguinal nerve (ilio-inguinal)**, having pierced the outer border of the psoas magnus lower down than, but close to, the ilio-hypogastric, passes obliquely outwards and downwards over the quadratus lumborum, where it may lie below the lower end of the kidney or behind it. It then passes forwards internal to the inner lip of the iliac crest beneath the transversalis abdominis. In this part of its course it rests upon the iliac fascia and iliacus muscle. Near the anterior part of the iliac crest it pierces the transversalis, and here communicates with the hypogastric branch of the ilio-hypogastric. It subsequently perforates the Poupart fibres of the internal oblique, after which it descends through the lower two-thirds of the inguinal canal, and emerges through the external abdominal ring, where it lies external to the spermatic cord. Finally, having pierced the intercolumnar fascia, it is distributed to the integument of the inner side of the thigh in its upper third, and the integument of the scrotum, or labium majus, according to the sex. The inguinal nerve in its course supplies branches to the internal oblique and transversalis abdominis muscles. It differs from the ilio-hypogastric and intercostal nerves in the following two respects : it does not give off any iliac or lateral cutaneous branch, and it is not distributed to the integument of the abdominal wall.

The **genito-crural nerve** passes forwards through the psoas magnus, and appears on its superficial surface about the level of the body of the third lumbar vertebra, where it lies close to the inner border of the muscle. It sometimes pierces the muscle in two parts, due to an early division of the nerve into its genital and crural branches. It then descends upon the psoas sheath, passing slightly outwards, and crossing behind the ureter. At a variable distance above Poupart's ligament (sometimes in the psoas magnus) the nerve divides into two branches, genital and crural. The *genital branch* lies upon the external iliac artery close above Poupart's ligament, and enters the inguinal canal through the internal abdominal ring to be distributed to the cremaster muscle. The *crural branch* descends on the outer side of the external iliac artery

and passes out behind Poupart's ligament, having, just prior to this, crossed the deep circumflex iliac artery. On entering the thigh it lies for about ½ inch within the crural sheath, and subsequently, piercing the outer wall of that sheath, it is distributed to the integument over Scarpa's triangle.

The **external cutaneous nerve** pierces the outer border of the psoas magnus near its centre, and takes a direction downwards and outwards over the back part of the iliac crest into the iliac fossa. It then crosses the iliacus under cover of the fascia iliaca towards the anterior superior iliac spine, where it emerges on to the thigh behind the outer end of Poupart's ligament. For the distribution of the nerve in the thigh, see p. 424.

The **anterior crural nerve** pierces the outer border of the psoas magnus about the level of the back part of the pelvic brim. It then passes forwards, lying deeply between the psoas magnus and iliacus, and emerges on to the thigh behind Poupart's ligament. Whilst in the abdominal cavity it gives branches to the iliacus muscle. The course and distribution of the nerve in the thigh will be found on p. 443.

The **obturator nerve** pierces the inner border of the psoas magnus at the back part of the pelvic brim, and it lies upon the ala of the sacrum, having the lumbo-sacral cord on its inner side. Passing deeply behind the common iliac artery it enters the pelvic cavity, and passes along the outer wall a little below the pelvic brim, where it lies above the obturator artery. It then emerges on to the thigh through the obturator canal. For the course and distribution of the nerve in the thigh, see p. 447.

The **accessory obturator nerve** (when present) pierces the inner border of the psoas magnus close to the main obturator nerve, but, unlike it, does not enter the pelvic cavity. Its course is forwards along the inner border of the psoas magnus underneath the external iliac vessels, and it emerges on to the thigh by passing over the superior pubic ramus beneath the pectineus muscle. Under cover of that muscle it divides into the following three branches: *articular* to the hip-joint; *muscular* to the deep surface of the pectineus; and a *reinforcing branch* to join the superficial or anterior division of the main obturator nerve.

Varieties of the Lumbar Plexus.—These assume the form of two types, high or prefixed, and low or postfixed. In the *prefixed type* the anterior primary division of the third lumbar is a nervus furcalis, and takes part in the sacral plexus, whilst in the *postfixed type* the anterior primary division of the fifth lumbar is a nervus furcalis, and takes part in the lumbar plexus.

Lumbo-sacral Cord.—This is formed by the union of the ventral and dorsal divisions of the descending branch of the fourth lumbar nerve with the ventral and dorsal divisions of the anterior primary division of the fifth lumbar. It is a large double trunk, which rests upon the ala of the sacrum, being at first under cover of the psoas magnus, and subsequently lying on its inner side, where it has the obturator nerve external to it. In its course it passes behind the common and internal iliac vessels, and in the pelvis, its two divisions having joined those of the anterior primary division of the first sacral nerve, it takes part in the sacral plexus, entering

more particularly the upper or outer band of that plexus which is continued into the great sciatic nerve.

The anterior primary division of the fourth lumbar nerve is known as a *nervus furcalis* from the fact that it is distributed partly to the lumbar and partly to the sacral plexus.

Lumbar Arteries.—These are branches of the abdominal aorta, being parietal in their distribution, and they are serially continuous with the aortic intercostal and subcostal arteries. They are eight in number, four right and four left, and they arise in pairs, separately or conjointly, from the posterior aspect of the parent trunk. They occupy the grooves at the centres of the bodies of the first four lumbar vertebræ. As each artery winds round a vertebral body it passes beneath one of the fibrous arches of the psoas magnus and the lumbar sympathetic gangliated cord. It then passes behind the psoas magnus and lumbar plexus, and, on reaching the interval between two adjacent lumbar transverse processes, it divides into two branches, dorsal and abdominal. The upper two arteries pass beneath the corresponding crus of the diaphragm, and those of the right side also pass beneath the receptaculum chyli and right azygos vein. All four arteries on the right side pass beneath the inferior vena cava. The trunk of each lumbar artery gives off a few vertebral branches to the body and ligaments of the adjacent vertebra, and muscular branches to the psoas magnus. The *dorsal branch* passes backwards between the adjacent transverse processes, in company with the posterior primary division of a spinal nerve, and it divides into an internal and external branch. The internal branch supplies the multifidus spinæ, and the external branch supplies the erector spinæ, giving also cutaneous branches which accompany the cutaneous nerves to the integument. Opposite an intervertebral foramen the dorsal branch furnishes a *spinal branch*, which enters the spinal canal through the foramen, to be distributed to the spinal cord and its coverings, as well as to the wall of the canal.

The *abdominal branch* is to be regarded as the continuation of a lumbar artery. These branches usually pass behind the quadratus lumborum, with the exception, as a rule, of that of the fourth. At the outer border of that muscle they pierce the posterior aponeurosis of the transversalis abdominis, and pass forwards between that muscle and the internal oblique, as far as the lower part of the rectus abdominis, which they enter. They furnish the following offsets, in order: muscular to the quadratus lumborum; capsular to the capsule of the kidney, which anastomose with branches of the renal artery; subperitoneal to the subperitoneal areolar tissue, which anastomose therein with branches of the ilio-lumbar, the inferior phrenic, and the hepatic, colic, and renal arteries, thus forming the subperitoneal arterial plexus of Turner; muscular to the abdominal muscles, which anastomose above with the lower two intercostal and subcostal arteries, below with the lateral or intermuscular epigastric of the deep circumflex iliac, and ilio-lumbar,

and in front with the deep epigastric. Sometimes there are five lumbar arteries on each side, the fifth pair coming usually from the middle sacral artery. Each of these passes beneath the corresponding common iliac vessels, and, having furnished a dorsal branch, usually to the gluteus maximus, it is distributed over the lateral mass of the sacrum and ends in the iliacus, where it anastomoses with the deep circumflex iliac artery.

The **lumbar veins** open into the inferior vena cava, those of the left side passing behind the abdominal aorta. The vessels of each side are connected by a series of longitudinal anastomosing veins in front of the lumbar transverse processes, and the longitudinal vessel thus formed is called the *ascending lumbar vein.*

Subcostal Artery.—This vessel is the last parietal branch of the thoracic aorta. It lies below the last rib, and is in series with the aortic intercostals above and the lumbar arteries below. It winds round the side of the body of the twelfth thoracic vertebra, and courses along the lower border of the twelfth rib with the subcostal nerve, passing behind the external arcuate ligament of the diaphragm and in front of the quadratus lumborum. This part of the vessel is behind the kidney and the ascending or descending colon, according to the side. Its subsequent course corresponds with that of the abdominal branches of the lumbar arteries. It anastomoses with the lower two intercostal arteries, the abdominal branches of the lumbar arteries, the lateral or intermuscular epigastric of the deep circumflex iliac, and the deep epigastric artery. This vessel has to be borne in mind in such operations as nephrotomy, nephrorrhaphy, and nephrectomy.

The **subcostal vein** of each side enters the thorax behind the external arcuate ligament of the diaphragm, the right opening into the right azygos vein, and the left into the lower left azygos vein.

Subcostal Nerve.—This is the anterior primary division of the twelfth thoracic nerve, and is in series with the eleventh or last intercostal. It accompanies the subcostal artery, and ultimately enters the sheath of the rectus abdominis, which muscle it pierces from behind forwards to become an anterior cutaneous nerve. In its course it gives off an undivided *lateral cutaneous* or *iliac branch*, which pierces the internal and external oblique muscles, and descends over the iliac crest to be distributed to the integument of the anterior part of the gluteal region. Besides this branch it furnishes the following offsets: (1) *dorso-lumbar* to the anterior primary division of the first lumbar nerve; and (2) branches to the quadratus lumborum, transversalis abdominis, internal oblique, and pyramidalis abdominis.

Lumbar Glands.—These are very numerous, and are divided into three groups—median, and two lateral, right and left.

The **median lumbar,** or **aortic, glands** are about twelve in number, and lie behind the parietal peritoneum, in front of, behind, and along the sides of the aorta (as high as the root of the superior mesenteric artery) and inferior vena cava. A few of the lower glands lie along

the common iliac arteries, and these are sometimes spoken of as the **common iliac glands.** The median lumbar glands receive their afferent vessels from the following sources: (1) the external iliac glands; (2) the internal iliac glands; (3) the sacral glands; (4) the efferent lymphatics of the testes in the male, and of the ovaries, Fallopian tubes, and upper end of the uterus in the female; (5) the kidneys; (6) the suprarenal capsules; (7) the vertebral part of the diaphragm; and (8) some of the efferent vessels of the lateral lumbar glands. Their efferent vessels unite to form two **lumbar lymphatic trunks,** right and left, which open into the lower end of

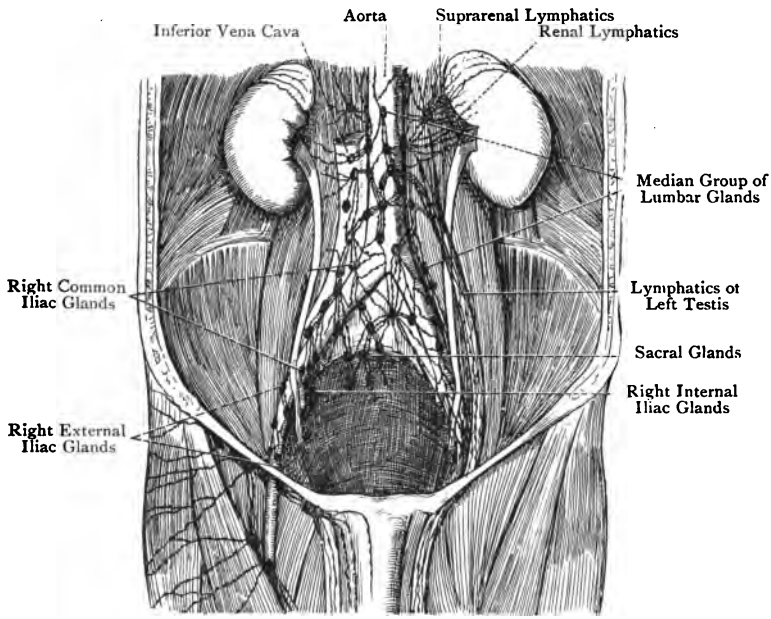


FIG. 323.—LYMPHATICS OF THE ABDOMEN (AFTER MASCAGNI).

the receptaculum chyli on a level with the body of the second lumbar vertebra. The left trunk receives the lymphatics of the lower part of the left colon, iliac colon, and pelvic colon.

The **lateral lumbar glands** are small but very numerous, being about twenty in number. They are situated behind the psoas magnus, where they lie between the lumbar transverse processes, and they receive their afferent vessels from the following sources: (1) the posterior abdominal wall and deep muscles of the back, and (2) the spinal canal. Some of their efferent vessels join the right and left lumbar lymphatic trunks, whilst others open independently into the lower end of the receptaculum chyli.

Common Iliac Arteries.—These vessels are the terminal

branches of the abdominal aorta. They arise from that vessel opposite the centre of the body of the fourth lumbar vertebra, a finger's breadth to the left of the middle line, and they at once diverge from each other. Their course is obliquely downwards and outwards over the lower portion of the body of the fourth and the whole of that of the fifth lumbar vertebra, as well as the disc between the two. Each artery, on arriving opposite the lumbo-sacral articulation, ends by dividing into external and internal iliac arteries. The length of the right common iliac is about 2 inches, and that of the left about 1¾ inches. The left vessel is less oblique in direction than the right, and the course of each may be indicated in the following manner: draw a line from a point fully 1 inch below the umbilicus, a finger's breadth to the left of the middle line, to a point at the groin midway between the anterior superior iliac spine and the symphysis pubis, and let this line be slightly curved with the convexity directed outwards. About the upper 2 inches of this line indicate the course of the common iliac artery, and the remainder that of the external iliac vessel.

Relations—*Anterior.*—The peritoneum, coils of the small intestine, one half of the aortic sympathetic plexus, and the ureter, which latter crosses the artery close to its termination, though it may be transferred to the commencement of the external iliac vessel. An additional superficial relation of the left common iliac artery is that it is crossed by the superior hemorrhoidal vessels.

Posterior.—Each artery rests upon the lower half of the body of the fourth and the whole of that of the fifth lumbar vertebra, as well as the disc above and below the latter, and the gangliated sympathetic cord. The **right** vessel is separated from the foregoing structures by the commencement of the inferior vena cava, the terminal part of the left common iliac vein, and the right common iliac vein, whilst the **left** vessel is free from posterior venous relations. Lying deeply behind each artery there are the obturator nerve, lumbo-sacral cord, and ilio-lumbar artery.

External.—On the outer side of the **right** vessel there are, from above downwards, the inferior vena cava, right common iliac vein, and psoas magnus. On the outer side of the **left** vessel is the psoas magnus.

Internal.—On the inner side of the **right** vessel, from below upwards, there are the right common iliac vein, the left common iliac vein, and the hypogastric sympathetic plexus. On the inner side of the **left** vessel there are the left common iliac vein, and the hypogastric plexus.

It is to be noted that the left artery is related only to its own vein, which lies on its inner side. The right artery, on the other hand, is related to three veins as follows: the inferior vena cava, which lies partly behind its upper end and partly on its outer side; the terminal part of the left common iliac vein, which lies partly on its inner side and partly behind it; and the right common iliac

vein, which, from below upwards, lies first on its inner side, then behind it, and finally on its outer side.

Branches.—These are as follows: peritoneal to the peritoneum and subperitoneal areolar tissue; muscular to the psoas magnus; ureteric to the ureter (all of small size and unimportant); external iliac; and internal iliac. In some cases the common iliac gives off one or other of the following vessels: ilio-lumbar, middle sacral, lateral sacral, lumbar, or an aberrant renal artery.

Varieties.—The chief variety affects the length of the vessel. It may be very short, which is due either to a low bifurcation of the aorta or a high bifurcation of the artery itself; or it may be very long, which is due to exactly opposite causes. When abnormally long, the vessel is usually more or less tortuous.

Collateral Circulation.—After ligature of a common iliac artery, the chief channels by which the circulation is carried on are as follows: (1) the superior epigastric of the internal mammary from the first part of the subclavian anastomoses with the deep epigastric of the external iliac; (2) the lumbar branches of the aorta anastomose with (*a*) the lateral or intermuscular epigastric of the deep circumflex iliac from the external iliac, and (*b*) the ilio-lumbar of the internal iliac; (3) the superior hemorrhoidal of the inferior mesenteric from the aorta anastomoses with (*a*) the middle hemorrhoidal of the internal iliac, and (*b*) the inferior hemorrhoidal of the internal pudic from the internal iliac; (4) the middle sacral from the aorta anastomoses with the lateral sacral branches of the internal iliac; and (5) the pubic branches of the obturator from the internal iliac and of the deep epigastric from the external iliac, both of one side, anastomose across the middle line with the corresponding branches of the opposite side. The vesical, and middle and inferior hemorrhoidal arteries of one side anastomose in a similar manner with those of the opposite side.

Common Iliac Veins.—Each vein is formed by the union of the external and internal iliac veins opposite the corresponding sacro-iliac articulation, on a level with the brim of the pelvis. They unite to form the inferior vena cava opposite the upper border of the body of the fifth lumbar vertebra a little to the right of the middle line, behind and on the right side of the right common iliac artery. The right vein is necessarily shorter than the left, and it ascends almost vertically, lying at first internal to, then behind, and finally on the outer side of its own artery. The left vein ascends very obliquely from left to right, lying internal to its own artery, and then behind that of the right side. It crosses the middle sacral artery, and is crossed by the superior hemorrhoidal vessels and the left half of the aortic plexus. The common iliac veins are usually destitute of valves.

Tributaries.—These are chiefly the external iliac, internal iliac, and ilio-lumbar. In addition, the left vein receives the middle sacral vein.

The *left* common iliac vein is mainly the persistent and enlarged *transverse branch* (transverse iliac) which connects the right and left cardinal veins of the embryo above the back part of the pelvic brim. Its commencement, however, is developed from a portion of the left cardinal vein. The *right* common iliac vein is developed from the part of the right cardinal vein which intervenes between the termination of the right external iliac vein and the right extremity of the transverse iliac vein.

External Iliac Artery.—This vessel is the larger of the two terminal divisions of the common iliac in the adult. It extends from the lumbo-sacral articulation to the lower margin of Poupart's ligament, where it is continued into the common femoral artery. Its course is along the pelvic brim, and at the groin it passes through the vascular lacuna at a point midway between the anterior superior iliac spine and the symphysis pubis. The line indicating the course of the vessel corresponds to the lower part of that which has been given as indicating the course of the common iliac. The vessel is from 3½ to 4 inches long, and its direction is downwards, outwards, and forwards.

Relations—*Anterior.*—The artery is covered by the parietal peritoneum and subperitoneal areolar tissue, the portion of the latter which is related to it being known as **Abernethy's fascia.** The right vessel at its commencement is crossed by the terminal part of the ileum, and sometimes by the vermiform appendix, whilst the left at its commencement is crossed by the pelvic colon, and each may be crossed by the ureter. In the female both arteries are crossed superiorly by the ovarian vessels. Near Poupart's ligament each vessel is crossed by the deep circumflex iliac vein, and the genital branch of the genito-crural nerve lies upon it. The spermatic vessels in the male also lie for a short distance upon it in this situation, and the vas deferens (or round ligament of the uterus) arches over it from without inwards. The external iliac glands lie along the artery. *Posterior.*—The artery rests upon the iliac fascia at the pelvic brim, except for a little above Poupart's ligament, where it lies upon the psoas muscle with the intervention of the iliac fascia, as that forms its sheath. The right artery at its commencement has its own vein behind it for a short distance, and each vessel may have the accessory obturator nerve as a deep posterior relation. *External.*—The psoas magnus covered by the iliac fascia, the genito-crural nerve, and its crural branch. *Internal.*—The peritoneum, the subperitoneal areolar tissue (Abernethy's fascia), which binds the artery with its vein to the iliac fascia, the external iliac vein (except for a short distance above on the right side, where the vein is behind its artery), and the vas deferens near Poupart's ligament.

Branches.—These are as follows: muscular to the psoas magnus; glandular to the external iliac glands (both unimportant); deep epigastric; and deep circumflex iliac. For the latter two, see pp. 623, 624.

Varieties of the Branches.—(1) The origin of the deep epigastric may be transferred to the common femoral, or to the arteria profunda femoris, and the deep circumflex iliac may be transferred to the common femoral. (2) The internal circumflex, obturator, or arteria profunda femoris may arise from the external iliac, in which latter case two large arteries would emerge on to the thigh beneath Poupart's ligament.

The **external iliac vein** is the continuation of the femoral vein. It extends from the lower border of Poupart's ligament to

the sacro-iliac articulation on a level with the brim of the pelvis, where it joins the internal iliac, and so forms the common iliac vein. There are usually two valves within it. Its chief tributaries are the deep epigastric and deep circumflex iliac veins, both joining it just above Poupart's ligament.

The external iliac vein of adult life is preceded in function by the sciatic vein of the embryo, which is the primitive vein of the lower limb. In the process of development the upper part of the femoral and the whole of the external iliac vein of the adult are continued upwards from the long saphenous vein to the cardinal portion of each common iliac vein, and the sciatic vein is now a tributary of the internal iliac.

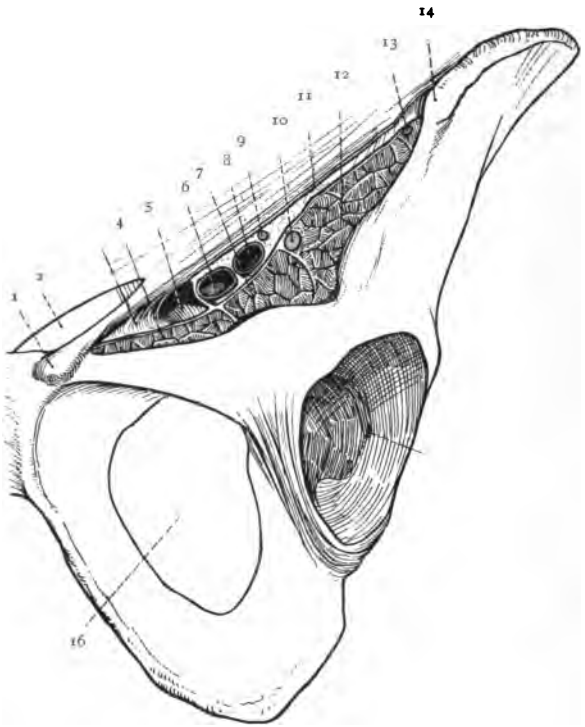
Collateral Circulation.—When the external iliac artery is ligatured, the collateral circulation is carried on through the following channels: (1) the superior epigastric of the internal mammary from the first part of the subclavian anastomoses with the deep epigastric of the external iliac; (2) the pubic branch of the obturator from the internal iliac anastomoses with the pubic branch of the deep epigastric; (3) the ilio-lumbar and gluteal, both from the internal iliac, and the abdominal branches of the lumbar arteries from the aorta anastomose with the deep circumflex iliac of the external iliac; (4) the obturator from the internal iliac anastomoses with the internal circumflex of the arteria profunda femoris; (5) the sciatic from the internal iliac anastomoses with the internal and external circumflex, and the first perforating of the arteria profunda femoris; (6) the gluteal anastomoses with the external circumflex and the ascending branch of the internal circumflex from the arteria profunda femoris; (7) the arteria comes nervi ischiadici of the sciatic anastomoses with the perforating branches of the arteria profunda femoris; and (8) the superficial perineal and dorsalis penis of the internal pudic from the internal iliac anastomose with the superior and inferior external pudics of the common femoral.

External Iliac Glands.—These are about nine in number, and they lie along the course of the external iliac artery. Three of them are usually related to the vessel just above Poupart's ligament, one being on its inner side, one upon it, and one external to it. They receive their afferent vessels from the following sources: (1) the deep femoral glands, (2) some of the efferent vessels of the inguinal and superficial femoral or saphenous glands, (3) the lymphatics from the regions supplied by the deep epigastric and deep circumflex iliac arteries, and (4) some of the lymphatics of the bladder. Their efferent vessels pass to the median lumbar glands, through the intervention of the so-called common iliac glands.

Lacunar Region.—The lacunar region is situated between Poupart's ligament and the anterior margin of the os innominatum, and is divided into two compartments—muscular and vascular.

The **muscular lacuna** is subdivided into two portions, external or iliac, and internal or pectineal, by the *ilio-pectineal septum*, which separates the psoas magnus from the pectineus. This septum passes between the ilio-pectineal eminence and the fascia iliaca at its point of junction with the upper part of the pubic portion of the fascia lata. The *iliac compartment*, which is of large size, is bounded in front by the outer part of Poupart's ligament and the iliac fascia, behind by the anterior margin of the ilium, and

internally by the ilio-pectineal septum. It transmits (1) the ilio-psoas muscle, (2) the external cutaneous nerve, and (3) the anterior crural nerve. The *pectineal compartment* is situated between the superior pubic ramus behind, and the upper part of the pubic lamina of the fascia lata in front, the ilio-pectineal septum being external to it. It contains the origin of the pectineus muscle, and



1. Pubic Spine
2. External Abdominal Ring
3. Gimbernat's Ligament
4. Pectineus
5. Crural or Femoral Ring
6. Femoral Vein
7. Psoas Magnus
8. Femoral Artery
9. Crural Branch of Genito-crural Nerve
10. Anterior Crural Nerve
11. Poupart's Ligament
12. Iliacus
13. External Cutaneous Nerve
14. Ant. Superior Iliac Spine
15. Acetabulum
16. Obturator Foramen

FIG. 324.—POUPART'S LIGAMENT AND THE LACUNAR REGION.

is shut off from the abdominal cavity by the attachment of the pubic lamina of the fascia lata to the pectineal portion of the ilio-pectineal line. In connection with this portion of the fascia lata there is a bundle of fibres, known as the *pubic ligament of Cooper*. This ligament extends between the ilio-pectineal eminence and the pubic spine, between which points it is attached to the pectineal portion of the ilio-pectineal line in front of Gimbernat's ligament, being closely incorporated with the pubic lamina of the fascia lata.

The **vascular lacuna** is situated anterior to the other two. It is bounded posteriorly by the connection between the iliac fascia and the pubic lamina of the fascia lata, whilst anteriorly it is bounded by the central portion of Poupart's ligament and the downward prolongation of the fascia transversalis to form the anterior wall of the crural sheath, that fascia being here strengthened by the deep crural arch. It gives passage to (1) the external iliac vessels, the vein being internal to the artery, and (2) the crural branch of the genito-crural nerve, which lies close to the outer side of the artery. The part of this lacuna internal to the external iliac vein forms the crural or femoral ring, which is closed by the septum crurale.

STRUCTURE AND DEVELOPMENT OF THE ABDOMINAL VISCERA

Structure of the Stomach.

The wall of the stomach is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, which covers every part of the organ except (1) along the great and small curvatures, and (2) the *uncovered trigone*, situated on the posterior surface, below and a little to the left of the cardiac orifice.

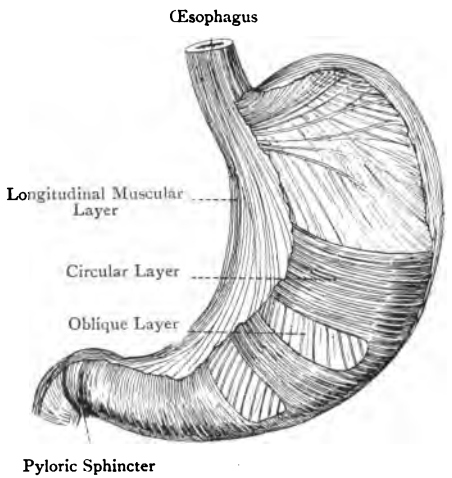


FIG. 325.—DISSECTION SHOWING THE MUSCULAR LAYERS OF THE STOMACH.

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue disposed in three layers—external or longitudinal, middle or circular, and internal or oblique. The *external* or *longitudinal fibres* are continuous with the longitudinal fibres of the œsophagus, and at the pyloric end of the stomach they are continuous with the longitudinal fibres of the duodenum. They are most abundant along the small curvature. The *middle* or *circular fibres* are continuous with the more superficial circular fibres of the lower end of the œsophagus. They commence on the right side of the cardiac orifice as a series of U-shaped bundles, which loop over the small curvature at the right of the cardia, and pass downwards and to the left on both surfaces

(Birmingham). When traced towards the right, these looped fibres gradually become circular, and form a complete investment to the stomach. At the pylorus they become augmented, and are gathered together into a thick muscular ring, called the **sphincter pylori,** the outermost fibres of which become continuous with the circular fibres of the duodenum. The *internal* or *oblique fibres* are continuous with the deeper circular fibres of the lower end of the œsophagus. They commence as U-shaped bundles, which loop over the stomach immediately to the left of the cardia, and run very obliquely downwards and to the right for a considerable distance on both surfaces of the organ. These looped fibres, on being traced towards

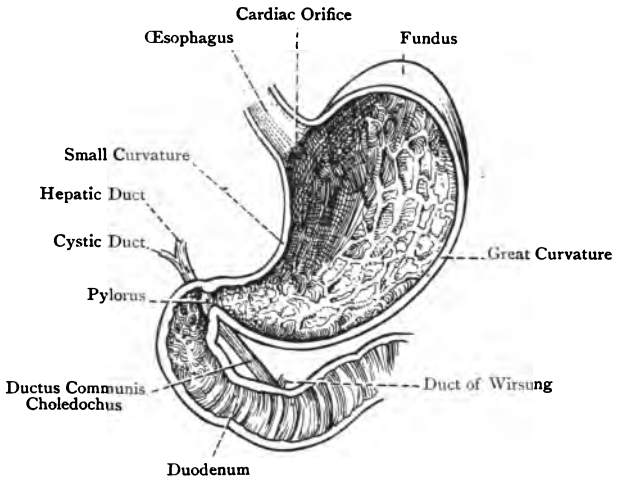


FIG. 326.—THE STOMACH AND DUODENUM OPENED.

the left, gradually become less oblique, and finally form circles which surround the wide end of the stomach completely, even as far as the summit of the fundus (Birmingham). The internal or oblique fibres embrace the cardiac orifice, round which they are disposed somewhat after the manner of a sphincter muscle. They cannot be traced as far as the pylorus, but end by inclining downwards to the great curvature, where they blend with the circular fibres.

The **submucous coat** is situated between the muscular and mucous coats. It is composed of loose areolar tissue, and serves partly as a connecting medium, and partly as a bed in which the arteries subdivide before entering the mucous coat.

The **mucous coat** is covered by a single layer of columnar epithelium, many of the cells being mucus-secreting goblet cells. It is soft and pulpy, and in the empty state of the viscus is thrown into rugæ, which are for the most part longitudinal, and are due to the loose connection between the muscular and mucous coats. These, however, are readily effaced when the stomach becomes distended.

It is thickest towards the pyloric end, and in healthy adults it has a light crimson colour, while in early life this is heightened into a bright rosy tint. After death, however, it presents a mottled appearance, being marked with grey-brown patches. When examined with a lens, it presents a great number of polygonal depressions, varying in diameter from $\frac{1}{100}$ to $\frac{1}{350}$ inch, the largest being near the pylorus. These impart to it a honeycomb appearance. The mucous membrane surrounding them is elevated into ridges by subjacent capillary networks, and in the region of the pylorus these ridges present processes, called *plicæ villosæ*. The polygonal depressions are beset with minute pores, which are the orifices of the **gastric glands.** These glands, which belong to the tubular variety, are placed perpendicularly in the mucous coat, and are closely packed together like upright stakes. They are of two kinds, cardiac and pyloric, between which there are certain differences.

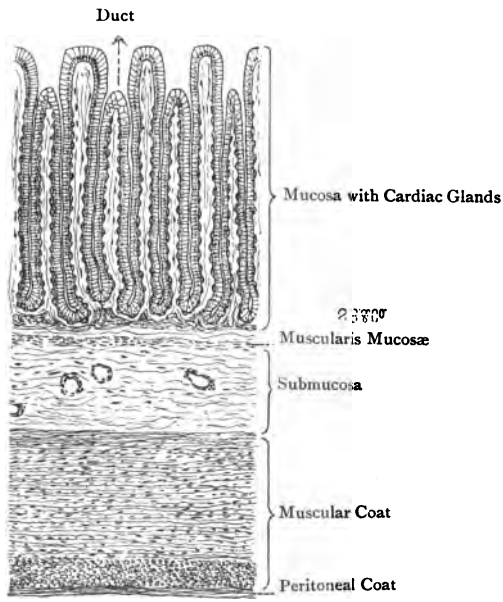


FIG. 327.—THE CARDIAC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

The **cardiac glands** are situated in the cardiac two-thirds. The **duct** of each forms about one-third of the entire length of the gland. It is lined with a single layer of columnar epithelium. The deep end of the duct is connected with two or three *gland-tubes*, which represent two-thirds of the entire gland. Each gland-tube is divisible into a neck, body, and fundus. The *neck* is the part connected with the duct, and it forms one-third of the length of the gland-tube. It is narrower than the body, and is lined with coarsely granular polyhedral cells, which almost completely fill it, thus leaving a very small lumen. These are called the **central** or **chief cells.** Between these and the basement membrane there are interposed large oval or spherical granular cells, each having a clear nucleus. These, which are called the **parietal** or **oxyntic** ('acid-forming') **cells,** do not form a continuous layer, but are placed at intervals, and they give rise to small swellings on the wall of the neck. The *body* is wider than the neck, and forms two-thirds of

the length of the gland-tube. It is lined by a prolongation of the central or chief cells of the neck, which almost completely fill it, and which have now become somewhat columnar and transparent. Between these cells and the basement membrane there are a few parietal or oxyntic cells here and there. The parietal cells of the neck and body impart the characteristic beaded appearance to the gland-tube. The *fundus* is the blind deep end of the gland-tube.

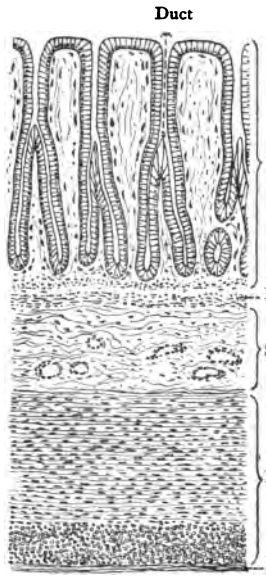


FIG. 328. — THE PYLORIC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

The **pyloric glands** are situated in the pyloric third. The duct of each forms one half of the entire length of the gland. It is lined with a single layer of columnar epithelium. The deep end of the duct is connected with two or three gland-tubes, which represent one half of the entire gland. The neck of each tube is comparatively short, and the body is branched at its deep extremity. The neck and body are lined with cubical granular cells, representing the central or chief cells of the cardiac glands, and they are not so crowded as in the cardiac glands, so that there is a very distinct lumen. There is an entire absence of parietal or oxyntic cells, and the body of each gland-tube has an undulating, convoluted outline. The pyloric glands are serially continuous with Brunner's glands of the small intestine.

Summary of the Cardiac and Pyloric Glands.

Cardiac Glands.	Pyloric Glands.
1. Ducts short.	1. Ducts long.
2. Gland-tubes long.	2. Gland-tubes short.
3. Gland-tubes almost filled with coarsely granular polyhedral cells, called central or chief cells.	3. Gland-tubes lined with cubical granular cells.
4. Lumen very small.	4. Lumen distinct.
5. Gland-tubes have parietal or oxyntic cells between the central cells and the basement membrane.	5. Gland-tubes destitute of parietal or oxyntic cells.

At the deepest part of the mucous coat, and forming a part of it, there is a stratum of plain muscular tissue, called the *muscularis mucosæ* (*muscularis interna*), which is disposed in two layers—outer longitudinal, and inner circular. The mucous membrane is also provided with lymphoid tissue in the interspaces between the deep ends of the gastric glands. In the cardiac part of the stomach this lymphoid tissue occurs in the form of isolated collections, called **lymph follicles,** which bear a resemblance to the solitary glands of the intestinal mucous membrane. In the neighbourhood of the pylorus these lymph follicles become aggregated, and so resemble somewhat the agminated glands or Peyer's patches of the small intestine.

Blood-supply—Arteries.—Along the small curvature there are (1) the gastric branch of the cœliac axis in two divisions, and (2) the pyloric branch of the hepatic, also in two divisions. Along the great curvature there are (1) the right gastro-epiploic of the gastro-duodenal of the hepatic from the cœliac axis, and (2) the left gastro-epiploic of the splenic from the cœliac axis. At the fundus there are the vasa brevia of the splenic artery.

The branches arising from all these arteries enter the muscular coat without piercing the peritoneum. They subsequently make their way inwards to the submucous coat, where they break up into branches which freely anastomose with one another. Fine branches then enter the mucous coat, which run upwards between the closely-packed gastric glands, round which they form by their anastomoses a delicate capillary network with its meshes elongated in the direction of the gland-tubes. From this network somewhat larger vessels proceed upwards, which by their anastomoses form a coarser and more superficial network around the orifices of the ducts of the glands.

Veins.—These arise from the superficial network of capillaries round the orifices of the ducts of the glands. They take a downward course between the gland-tubes, and on reaching their deep ends they form a plexus. From this plexus branches proceed outwards to the submucous coat, in which they form another plexus. The branches arising from this latter plexus, having passed through the muscular coat, terminate in the following veins: (1) the right gastro-epiploic, which opens into the superior mesenteric; (2) the left gastro-epiploic and vasa brevia, which open into the splenic; (3) the gastric; and (4) the pyloric, the latter two opening directly into the vena portæ. The veins of the stomach contain numerous valves, which are sufficiently competent in early life to oppose the return of venous blood, but in the adult they are incompetent.

Lymphatics.—These commence near the free surface of the mucous membrane either in loops or in enlargements, and they take a downward course between the gland-tubes, where they open into a network of lacunar spaces. The branches which proceed from this network on reaching the deep ends of the glands form a plexus,

and the vessels issuing from this plexus on entering the submucous coat form another plexus, the lymphatics of which are furnished with valves. The vessels which emerge from this latter plexus accompany the bloodvessels, and pass to the small and great curvatures, and the vicinity of the hilum of the spleen. At the curvatures they are connected with the superior and inferior gastric lymphatic glands, whilst those which accompany the vasa brevia arteries pass through the splenic glands, the efferent vessels of all these glands ultimately passing to the cœliac glands. In addition to the lymphatic vessels just described there is a subperitoneal lymphatic plexus.

Lymphatic Glands.—These form two groups—superior and inferior. The *superior glands* are about six in number, and are situated along the small curvature. They receive as afferent vessels the superior gastric lymphatics, and their efferent vessels pass to the cœliac glands. The *inferior glands* are about eight in number, and are situated along the great curvature. They receive as afferent vessels the inferior gastric lymphatics, and those of the gastro-colic omentum, and their efferent vessels pass to the cœliac glands.

Nerves.—These are derived from (1) the two pneumogastric nerves, and (2) sympathetic plexuses from the solar plexus. The **right** pneumogastric nerve descends upon the *posterior surface* of the stomach, whilst the **left** nerve descends upon the *anterior surface*. The sympathetic plexuses closely accompany the arteries. The nerves form two gangliated plexuses composed of non-medullated nerve-fibres. One of these is situated between the longitudinal and circular fibres of the external muscular coat, and corresponds to the plexus myentericus of Auerbach of the intestine. The other plexus is situated in the submucous coat, and corresponds to the plexus of Meissner of the intestine.

The explanation of the right pneumogastric nerve descending upon the posterior surface, and the left upon the anterior surface, of the stomach is found in the position assumed by the stomach in the early embryo. Briefly stated, at that period of life the stomach is a straight tube, and its surfaces are right and left. The two pneumogastric nerves, therefore, right and left, naturally descend on the right and left surfaces of the viscus. When, however, the stomach turns over on its right side, the surface which was originally right becomes posterior, and the surface which was originally left becomes anterior. Thus the right nerve eventually descends on the posterior (originally the right) surface, and the left nerve descends on the anterior (originally the left) surface.

Pylorus.—The opening between the pyloric end of the stomach and the duodenum is provided with a sphincter muscle, called the *sphincter pylori*. This is formed by an aggregation of the *circular* muscular fibres, and it causes the mucous membrane to project in the form of an annular fold, which is called the **pyloric valve,** or **pylorus.** The sphincter pylori is only relaxed when the contents of the stomach are being passed into the duodenum. At all other times it is in a condition of firm contraction, and the pyloric orifice then takes the form of a cleft.

The average length of the stomach is about 12 inches, and its average width at the widest part about 5 inches. It weighs about 4½ ounces, and its capacity, which is very variable, ranges from 3 to 5 pints.

Structure of the Intestinal Canal.

Small Intestine.—The wall of the small intestine, which is cylindrical, is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by peritoneum derived from the mesentery proper. In the case of the duodenum it is incomplete, but it forms a complete investment to the jejunum and ileum, except along a narrow interval corresponding to the mesenteric border of the bowel, where the peritoneal investment becomes continuous with the two layers of the mesentery proper.

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue, disposed in two layers, external or longitudinal, and internal or circular. The *external* or *longitudinal fibres* are continuous with the corresponding fibres of the stomach, and they are best marked along the anti-mesenteric border. The *internal* or *circular fibres* are continuous with the outermost fibres of the sphincter pylori, and form a much thicker layer than the longitudinal. The muscular coat attains its greatest thickness in the duodenum, whence it gradually diminishes. Between the two muscular layers there is a gangliated plexus of non-medullated nerve-fibres, called the **plexus myentericus of Auerbach,** and also a plexus of lymphatic vessels.

The **submucous coat** is situated between the muscular and mucous coats. It is composed of loose areolar tissue, and serves partly as a connecting medium and partly as a bed in which the arteries subdivide. It contains a gangliated plexus of non-medullated nerve-fibres, called the **plexus of Meissner,** and a plexus of lymphatic vessels. In the duodenum this coat lodges Brunner's glands, and the deep ends of the solitary glands project into it throughout.

The **mucous coat** is red and thick in the upper part of the small intestine, but pale and thin in the lower part. It is covered by a single layer of columnar epithelium, many of the cells being mucus-secreting goblet cells. The protoplasm of the cells is longitudinally fibrillated, and their free ends are covered by a delicate *striated basilar border,* the striations being vertically disposed. Underneath the epithelium there is a basement membrane, known as the *sub-epithelial endothelium,* and underneath this is the main part of the mucous coat, which is essentially composed of adenoid tissue, that is to say, retiform tissue containing in its meshes lymph corpuscles. At the deepest part of the mucous coat, and forming a part of it, there is a stratum of plain muscular tissue, called the *muscularis mucosæ* (*muscularis interna*), which in many situations is disposed in two layers—outer longitudinal, and inner circular.

In some places, however, only the outer longitudinal layer is present. The mucous coat is beset all over with minute projections, called villi, and is sometimes called the **villous coat.** These villi impart to it a woolly appearance like the nap of velvet. It diminishes in thickness from above downwards, and is characterized by the following structures: (1) valvulæ conniventes, (2) villi, (3) Brunner's glands, (4) crypts or follicles of Lieberkühn, (5) solitary glands, and (6) agminated glands or Peyer's patches.

Of the foregoing structures the valvulæ conniventes, villi, and Peyer's patches constitute the *macroscopical* (naked-eye) characters of the mucous membrane, the others forming its *microscopical* characters.

The **valvulæ conniventes** (valves of Kerkring) are permanent folds of the mucous membrane, which cannot be effaced. They are absent from the first part of the duodenum for a distance of from 1 to 2 inches from the pylorus. Commencing about the upper end of the second part of the duodenum as small straggling folds, they become large and distinct at the place of entrance of the ductus communis choledochus and pancreatic duct (about 4 inches from the pylorus). Throughout the rest of the duodenum and in the upper part of the jejunum they are still prominent, and are placed close to each other. In the lower part of the jejunum they become smaller, and are placed farther apart. In the upper part of the ileum they become still smaller and more irregular, and they finally disappear just beyond the centre of the ileum. They are crescentic folds placed across the bowel, and each consists of two layers of mucous membrane applied back to back, with a little submucous areolar tissue intervening. Their average length is about 2½ inches, and the average breadth of each is about ⅓ inch. The majority of them extend round the bowel for from one-half to two-thirds of its circumference. Some, however, describe complete circles, whilst a few are arranged in a spiral manner so as to describe from one to three turns round the tube. Some of them begin and terminate in bifurcated extremities, whilst others present abrupt single extremities. The purpose served by the valvulæ conniventes is a twofold one. In the first place they increase the extent of the absorbing and secreting surface of the mucous membrane, and in the second place they delay the passage of the intestinal contents, and so afford time for digestion and absorption.

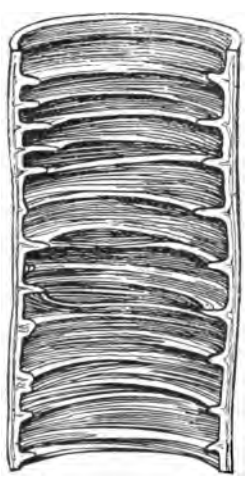


FIG. 329.—THE VALVULÆ CONNIVENTES.

In connection with the valvulæ conniventes of the duodenum the common orifice of the ductus communis choledochus and

pancreatic duct has to be noted. At the junction of the inner and posterior aspects of the second part of the duodenum where the upper two-thirds and lower third of that part meet, there is a small eminence of the mucous membrane, called the **bile papilla.** It lies at the lower end of a vertically-placed valvula connivens, which bifurcates so as to form a kind of cap for it. From the lower part of the papilla a fold extends downwards for some distance, which acts as a bridle, and gives the apex a downward direction. On the summit of this papilla there is an opening which represents the common orifice of the two ducts. These ducts, having traversed the wall of the second part of the duodenum obliquely for $\frac{3}{4}$ inch, unite to form one duct which, before piercing the mucous coat, presents an enlargement called the **ampulla of Vater,** but subsequently narrows at its final ending. In the ampulla of Vater a gallstone may become lodged and delayed in its downward progress toward the duodenum. About 1 inch above the bile papilla there is another small papilla upon which there is another minute opening. This represents the orifice of the accessory pancreatic duct, or duct of Santorini.

The **villi** commence at the beginning of the duodenum on the outer side of the pylorus, and extend as far as the margins of the segments of the ileo-cæcal valve. They are minute projections of the mucous membrane, to which they impart a woolly appearance, and may be visible to the naked eye, but are more readily seen with the aid of an ordinary lens if a portion of bowel is floated in water. They are closely set upon the mucous membrane (valvulæ conniventes included), except over the solitary glands. Their total number is said to be about four millions (Krause). The villi are conical, cylindrical, leaf-like or finger-like processes, varying in length from $\frac{1}{30}$ to $\frac{1}{40}$ inch. They are larger and more numerous in the lower part of the duodenum and in the jejunum, especially at its upper part, than in the ileum, and they diminish both in size and number from above downwards, becoming somewhat filiform in the ileum. Each villus is an elevation of the mucous membrane covered by a single layer of columnar epithelium. It is composed of (1) adenoid tissue, (2) a capillary network of

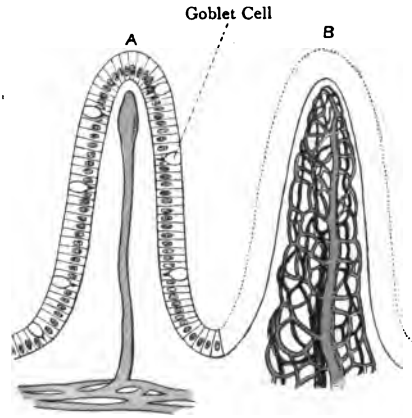


FIG. 330.—TWO VILLI.

A. Villus, showing Striated Basilar Border, Columnar Epithelium, Goblet Cells, and Lacteal Vessel. B. Villus, showing the Capillary Bloodvessels.

bloodvessels, (3) one or more lacteal vessels ensheathed by plain muscular tissue; and (4) arborisations of nerve-fibrils derived from the plexus of Meissner.

Between the columnar epithelial cells of the free surface, many of which are mucus-secreting goblet cells, there are amœboid lymph corpuscles. Beneath the epithelium is a basement membrane composed of flattened cells, and known as the *subepithelial endothelium.* The cells of this basement membrane send processes outwards between the columnar cells of the free surface, and they also send processes inwards which are connected with the branched cells of the retiform tissue of the adenoid tissue. One artery (sometimes two) enters the base of the villus and ascends to near the centre. Here it breaks up into a number of branches, which form a copious capillary network. From this plexus the blood is returned by one or two venous radicles, which leave the villus at its base, where they open into the venous plexus of the mucous membrane. In the centre of the villus there is a **lacteal vessel,** which commences near the tip in a blind bulbous extremity, or, if there should be two lacteals, they originate in the form of a loop. The wall of the lacteal vessel is formed by a single layer of endothelial plates, which are connected by processes with the branched cells of the retiform tissue of the adenoid tissue. The vessel is ensheathed by longitudinal plain muscular fibres derived from the muscularis mucosæ, their fibre-cells being connected with the basement membrane of the villus. The villus is pervaded by adenoid tissue—that is to say, retiform tissue with its meshes filled with amœboid lymph corpuscles. The branched cells of this retiform tissue are connected by processes on the one hand with the endothelial plates which compose the wall of the lacteal vessel, and on the other hand with the cells of the basement membrane near the surface, and these latter in turn send out processes between the columnar epithelial cells of the free surface.

The villi play a most important part in absorption, partly through their copious capillary networks, and partly through their lacteals. The lacteals serve specially for the absorption of fats, which is probably effected in the following manner : the columnar epithelial cells at the free surface take up the saponified and emulsified fats, which they transfer to the amœboid lymph corpuscles between them. These corpuscles then carry the fats inwards through the adenoid tissue into the lacteal vessel.

Brunner's glands are confined to the duodenum, and are serially continuous with the pyloric glands of the stomach. They are very numerous in the commencement of the duodenum, where they form a continuous layer of gland tissue extending as low as the entrance of the common bile-duct and pancreatic duct. Beyond this point they gradually diminish in number, and ultimately disappear near the duodeno-jejunal flexure. They belong to the class of racemose or acino-tubular glands, and they differ from the pyloric glands of the stomach in having their tubules

more branched, and in having longer ducts. Otherwise the structure of the two kinds of glands is similar. Brunner's glands lie embedded in the submucous coat, and their long ducts pass through the whole thickness of the mucous coat, upon the surface of which they open between the crypts of Lieberkühn. Some of them, however, open into these crypts. The glands can easily be displayed by removing the peritoneal and muscular coats of the duodenum and a little of the submucous areolar tissue, when they appear as small, round, grey-coloured masses like millet seeds, varying in diameter from $\frac{1}{12}$ to $\frac{1}{50}$ inch.

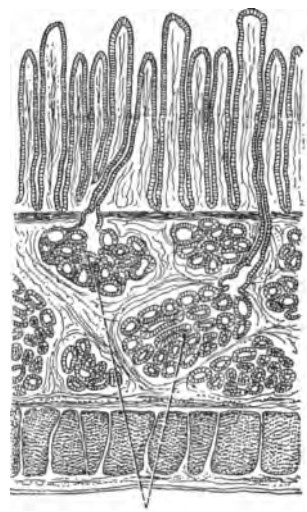


FIG. 331.—SECTION OF THE DUODENUM, SHOWING BRUNNER'S GLANDS (HIGHLY MAGNIFIED).

The **crypts** or **follicles of Lieberkühn** are found in large numbers over the whole of the mucous membrane of the small intestine, as well as that of the large bowel. They belong to the class of simple tubular glands, and are to be regarded as small diverticula of the mucous membrane. Each crypt takes the form of a simple tube, which is closed and slightly enlarged at its deep extremity, and opens by its other end on the surface between the villi. The crypts are present on the valvulæ conniventes as well as in the intervening parts. They are placed vertically and close together, and are confined entirely to the mucous coat, in which they extend from the free surface to the muscularis mucosæ. In length they vary from $\frac{1}{60}$ to $\frac{1}{180}$ inch. Each crypt is composed of a basement membrane lined with columnar epithelium, many of the cells being mucus-secreting goblet cells, and the lumen is of large size.

The **solitary glands** are present over the whole extent of the mucous membrane of the small intestine. They assume the form of small white round or oval nodules, which project by their deep ends into the submucous coat, whilst their superficial ends give rise to slight elevations of the free surface, where they have the openings of the crypts of Lieberkühn placed around them. They are found upon, as well as between, the valvulæ conniventes. In structure each solitary gland is composed of adenoid tissue containing large numbers of lymph corpuscles, and permeated by capillary networks. Each gland is surrounded at its deep part by a copious plexus of lymphatic vessels, or by lymphatic sinuses. The solitary glands are simply lymphoid nodules.

The **agminated glands or Peyer's patches** are peculiar to the

small intestine, and average about thirty in number in the adult, being more numerous in early life. They are situated along the free or anti-mesenteric border of the bowel, which must, therefore, be opened along its attached or mesenteric border in order to preserve them. They are largest, best marked, and most plentiful in the lower half of the ileum. In the upper part of the ileum and

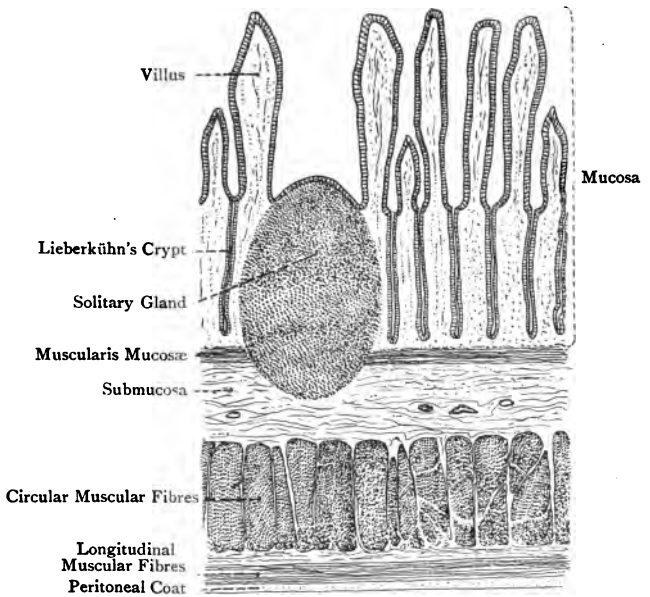


FIG. 332.—VERTICAL TRANSVERSE SECTION OF THE SMALL INTESTINE (HIGHLY MAGNIFIED).

lower part of the jejunum they become smaller and more scarce, and they disappear as a rule above the centre of the jejunum. They vary in length from $\frac{1}{2}$ inch to 4 inches, their breadth ranging from $\frac{1}{2}$ inch to 1 inch. They are for the most part oblong, their long axis coinciding with that of the bowel. In the upper part of the ileum and lower part of the jejunum, however, they are somewhat circular. Each patch is composed of a group of solitary glands or lymphoid nodules, surrounded by lymphatic plexuses or lymphatic sinuses. The area of each patch is slightly elevated, and there are no villi over the lymphoid nodules, whilst the openings of the crypts of Lieberkühn are arranged in a circular manner round each nodule. There are no valvulæ conniventes over Peyer's patches. The patches are best marked in young persons. Towards middle life they fade away, and in old persons they are usually only distinguishable as discoloured portions of the mucous membrane.

Blood-supply—Arteries.—The duodenum receives its arteries from the superior pancreatico-duodenal of the gastro-duodenal from the hepatic, and the inferior pancreatico-duodenal of the superior mesenteric. The jejunum receives its arteries from the rami intestini tenuis of the superior mesenteric. The ileum also receives its arteries from the rami intestini tenuis, and its terminal part in addition receives its arterial supply from the ileal branch of the ileo-colic from the superior mesenteric.

Veins.—The destination of the venous blood of the small intestine is the superior mesenteric vein, and thereafter the vena portæ. The veins are provided with valves which are competent in early life, but in the adult they are incompetent, and therefore allow regurgitation of blood to take place towards the small intestine, as happens in cases of portal obstruction.

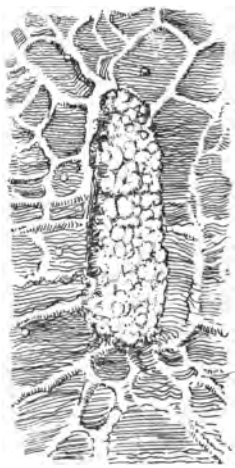


FIG. 333.—A PEYER'S PATCH.

Lymphatics.—These form a copious plexus of valved vessels, which is situated in the submucous coat. This plexus receives the lymphatics of the mucous membrane and the lacteals of the villi, and it surrounds the deep ends of the solitary glands. Its efferent vessels pierce the muscular coat, and in doing so they take up the lymph from an intramuscular plexus of lymphatics, which lies between the longitudinal and circular layers. They then leave the bowel at the mesenteric border, where they pass between the two layers of the mesentery, and on their way to the receptaculum chyli they traverse the mesenteric glands.

Nerves.—These are derived from the superior mesenteric sympathetic plexus, and they form two gangliated plexuses of non-medullated nerve-fibres. One of these is situated in the muscular coat between the longitudinal and circular layers, and is known as the **plexus myentericus of Auerbach** (plexus of the muscular coat of the intestine). The other is situated in the submucous coat, and is called the **plexus of Meissner.** The branches of this latter plexus are distributed to the muscularis mucosæ and the mucous membrane with its villi.

Characters of Different Parts of the Small Intestine—Duodenum—*Peritoneum.*—There is no mesentery and only a partial investment of peritoneum. *Muscular Coat.*—This is very thick. *Submucous Coat.*—This contains the tubular portions of Brunner's glands. *Mucous Coat.*—The characters of this coat are as follows: (1) valvulæ conniventes, except in the first 1 or 2 inches, (2) villi, (3) Lieberkühn's crypts, (4) solitary glands, (5) ducts of Brunner's glands, (6) common orifice of the ductus communis choledochus and pancreatic duct, and (7) orifice of the accessory pancreatic duct, or duct of Santorini.

The diameter of the duodenum is from 1½ to 2 inches.

Jejunum—*Peritoneum.*—There is a mesentery, and the bowel is surrounded by peritoneum except along its mesenteric border. *Muscular Coat.*—This is comparatively thin. *Mucous Coat.*—This has the following characters: (1) valvulæ conniventes, (2) villi in abundance, (3) Lieberkühn's crypts, (4) solitary glands, and (5) Peyer's patches in its lower half.

The diameter of the jejunum is about 1½ inches.

Ileum—*Peritoneum.*—In this respect the ileum resembles the jejunum. *Muscular Coat.*—This is very thin. *Mucous Coat.*—The characters of this coat are as follows: (1) valvulæ conniventes in upper half, but small and sparse, there being none in the lower half; (2) villi, but in fewer numbers; (3) Lieberkühn's crypts; (4) solitary glands; and (5) Peyer's patches.

The diameter of the ileum is about 1¼ inches.

Large Intestine.—The wall of the large intestine, which is sacculated, is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** forms a complete investment to the vermiform appendix, cæcum, transverse colon, and pelvic colon. As regards the ascending colon, descending colon, and iliac colon, it is incomplete, being absent *behind.*

The **muscular coat** (*muscularis externa*) is composed of plain muscular tissue, disposed in two layers—external or longitudinal, and internal or circular.

The *longitudinal muscular fibres* are for the most part collected into three flat bands, called **tæniæ coli,** or **ligaments of the colon,** except upon the rectum. In the intervals between these bands there are some longitudinal fibres, but they are very few and scattered. The tæniæ, which are about ¼ inch in breadth, commence upon the cæcum at the base of the vermiform appendix, and they extend along the several parts of the large intestine as far as the rectum, where they spread out and form a continuous covering, which completely surrounds that part of the bowel. Upon the cæcum, ascending colon, descending colon, and iliac colon the tæniæ from their disposition are called anterior, postero-internal, and postero-external. Upon the transverse colon they are so placed as to be called anterior or omental (great omentum), postero-inferior, and superior or meso-colic (transverse meso-colon). They are shorter than the bowel to which they are applied, with the result that the tube is drawn together or puckered, and thus thrown into sacculi. There being three tæniæ, there are three rows of sacculi between them, and, inasmuch as the tæniæ are placed at nearly equal distances from each other, the sacculi are pretty much of equal dimensions. Between the successive sacculi there are constrictions, usually containing fat. The sacculi give rise internally to large pouches, and the constrictions between the sacculi produce internally sharp crescentic rugæ, which separate the pouches from each other. When the tæniæ are divided, the sacculi and constrictions entirely disappear, and the large bowel becomes elongated into a smooth cylindrical tube. Along the course of the tæniæ there are a number of small processes of peritoneum containing fat, called **appendices epiploicæ.**

Except in the case of the transverse colon, these are chiefly found along the postero-internal tænia, but in the case of the transverse colon they are principally met with along the postero-inferior tænia.

The *circular* fibres are thin and scattered over the sacculi, but in the constrictions between them they become aggregated. Upon the rectum and anal canal they form a thick layer, which in the latter situation is known as the sphincter ani internus.

The **submucous coat** is in all respects similar to that of the small intestine.

The **mucous coat** is pale and greyish in colour, except in the rectum, where it is red. Its epithelium is similar to that of the small intestine. It is destitute of valvulæ conniventes and villi, and consequently presents a smooth surface. It contains large numbers of the crypts or follicles of Lieberkühn, which abound in mucus-secreting goblet cells. It also contains solitary glands or lymphoid nodules, which are especially prevalent in the vermiform appendix and cæcum. The deepest part of the mucous coat is formed by the *muscularis mucosæ* (*muscularis interna*).

Blood-supply—Arteries.—These are as follows: (1) appendicular, for the vermiform appendix; (2) anterior and posterior cæcal, for the cæcum; (3) colic of ileo-colic, and right colic, for the ascending colon; (4) middle colic, for the transverse colon (all branches of the superior mesenteric); (5) left colic, for the descending colon; and (6) sigmoid arteries, for the iliac colon and pelvic colon (the latter two being branches of the inferior mesenteric).

Veins.—The destination of the venous blood of the vermiform appendix, cæcum, ascending colon, and transverse colon is the superior mesenteric vein, whilst the blood of the descending colon, iliac colon, and pelvic colon is carried into the inferior mesenteric vein. In both cases the further destination of the blood is the vena portæ. As in the small intestine, the veins have valves which are competent in early life, but not so in the adult.

The **lymphatics** will be found described on pp. 684 and 685.

Nerves.—These are derived from the superior mesenteric sympathetic plexus, and the inferior mesenteric plexus, which latter is an offshoot from the aortic plexus. The disposition of the nerves corresponds with that in the small intestine.

The large intestine diminishes gradually in size from its commencement to its termination. Its diameter varies in different parts, the extremes being 2½ inches and 1 inch.

Characters of the Large Intestine—*Peritoneal Coat.*—This presents at frequent intervals small projections called appendices epiploicæ. *Muscular Coat.*—The longitudinal fibres are for the most part arranged in three tæniæ. *Mucous Coat.*—This is destitute of (*a*) valvulæ conniventes, (*b*) villi, (*c*) Brunner's glands, and (*d*) Peyer's patches, but it is provided with (1) Lieberkühn's crypts, and (2) solitary glands or lymphoid nodules. *Outline of Tube.*—The bowel presents three rows of sacculi, except in the vermiform appendix and rectum.

Structure of the Vermiform Appendix.—The vermiform appendix is entirely covered by peritoneum, which forms a more or less complete meso-appendix or appendicular mesentery. It has a muscular coat, composed of an external longitudinal and internal circular layer, both of which completely surround it. The

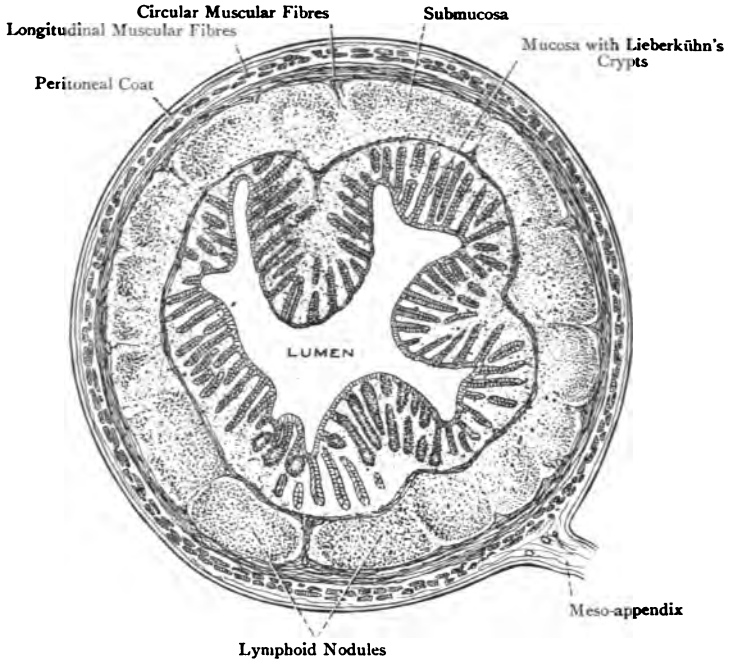


FIG. 334.—TRANSVERSE SECTION OF THE VERMIFORM APPENDIX (HIGHLY MAGNIFIED).

submucous coat contains, in great abundance, lymphoid nodules (solitary glands) of large size, and the mucous coat contains a few lymphoid nodules, as well as a few crypts of Lieberkühn. The base of the appendix is situated at a point on an average rather more than 1 inch below the ileo-cæcal valve according to Treves. The opening by which the appendix communicates with the cæcum is occasionally guarded by a fold of mucous membrane, which is known as the **valve of Gerlach.**

The vermiform appendix is usually regarded as the remains of the herbivorous cæcum. It is also looked upon as an appendage of the lymphoid system, and as such it would belong to the class of structures represented by Peyer's patches, namely, lymphoid organs. In its typical form it is peculiar to man, the higher apes, and the marsupial wombat. In certain rodents, however—*e.g.*, the rabbit and hare—the very large capacious cæcum shows an approach to a vermiform appendix at its lower extremity.

Ileo-cæcal or **Ileo-colic Valve** (valve of Tulpius).—This valve is situated at the point where the terminal part of the ileum opens into the junction between the cæcum and ascending colon. The orifice, as seen from the interior of the large intestine, has the form of a slightly oblique cleft about ½ inch long, and running in an antero-posterior direction. It is bounded above and below by the two segments which form the valve, and which project into the large intestine. The upper or *ileo-colic segment* is crescentic, and occupies a horizontal plane. The lower or *ileo-cæcal segment*, larger than the upper, is also crescentic, and occupies an oblique plane. The anterior part of the cleft is rounded off, whilst the

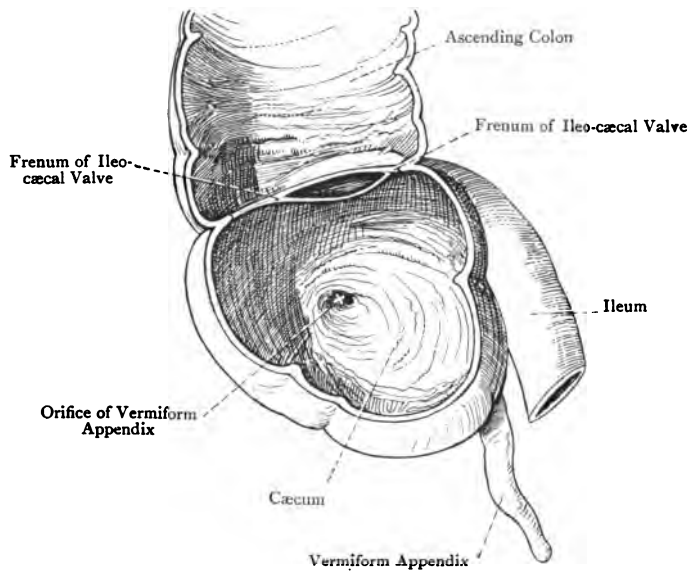


FIG. 335.—THE INTERIOR OF THE CÆCUM AND THE ILEO-CÆCAL VALVE.

posterior part tapers to a point. The segments meet in front of and behind the cleft, and form two prominent folds, which are prolonged round the wall of the bowel for some distance. These folds are known as the *frena* or *retinacula of Morgagni*. Each segment is composed of two layers of mucous membrane, one of which belongs to the ileum, and the other to the cæcum or colon as the case may be. These two layers are continuous with each other at the free margin of the segment, and they contain between them submucous areolar tissue and circular muscular fibres, both of which are derived partly from the ileum and partly from the large intestine. The longitudinal muscular fibres and the serous or peritoneal coat take no part in the formation of the segments, being continued uninterruptedly from the ileum to the large

intestine. The mucous membrane which covers the opposed surfaces of the segments belongs to the ileum, and is, therefore, provided with villi. The mucous membrane of the other surfaces, that is to say, the surfaces which look away from each other (downwards and upwards respectively), belong to the cæcum and colon, and are destitute of villi. The villi thus disappear at the margins of the segments. The valve may be described as being formed by an inversion of the terminal part of the ileum into the large intestine. That part of the ileum, having passed upwards and to the right with a slight inclination backwards, enters the large intestine. As it does so, it leaves behind its serous and longitudinal muscular coats, and takes with it its circular muscular, submucous, and mucous coats, the corresponding coats of the large intestine accompanying it in the inversion. The ileo-cæcal valve prevents the regurgitation of the contents of the cæcum into the ileum. It is generally believed that the mode of action of the valve is as follows: when the cæcum becomes distended the frænа or retinacula of the valve are stretched, and exercise traction upon its segments, which are thereby brought together, very much as an old-fashioned purse is closed by pulling upon the two strings.

For the structure of the rectum, see p. 818.

Development of the Stomach, Intestinal Canal, and Peritoneum.—The primitive alimentary canal, which lies beneath (on the ventral aspect of) the notochord, is limited anteriorly by the head-fold, posteriorly by the tail-fold, and on either side by a lateral fold. It is arranged in three divisions, namely, the fore-gut, the mid-gut, and the hind-gut. The **fore-gut,** which is placed within the head-fold, gives rise to (*a*) the tongue and back part of the buccal cavity, (*b*) the pharynx, (*c*) the œsophagus, (*d*) the stomach, and (*e*) the greater part of the duodenum, as well as the organs developed as outgrowths from these parts. The **mid-gut,** gives rise to (*a*) a part of the duodenum, (*b*) the jejunum, (*c*) the ileum, and (*d*) the large intestine, except a portion of the colon at its lower end, the rectum, and the anal canal. The **hind-gut** is contained within the tail-fold, and gives rise to (*a*) the portion of the colon not developed from the mid-gut, (*b*) the rectum, and (*c*) the portion of the anal canal *above* the anal valves. The portion of the anal canal *below* the anal valves, and the anus are developed from the posterior part of the cloacal fossa, which is called the **proctodæum.** The mid-gut remains for some time in free communication with the yolk-sac. The communication is at first a wide one, but a constriction soon takes place in the region of the umbilical orifice, so that the mid-gut and yolk-sac now communicate by a comparatively narrow neck or duct. The abdominal wall being now formed, and the yolk-sac lying outside the body of the embryo, this duct runs inwards from the yolk-sac along the umbilical cord and through the umbilicus, after which it joins by its other end the mid-gut. The duct is variously known as the *umbilical, vitelline,* or *vitello-intestinal duct.* The part of the mid-gut which is connected with this duct gives rise to the lower portion of the ileum, and the occasional occurrence of **Meckel's diverticulum** in that part of the gut is due to the intestinal portion of the vitelline duct remaining persistent. At this period of embryonic life the primitive alimentary canal has only one opening, namely, that by which it communicates with the yolk-sac through the vitelline duct, its cephalic and caudal ends being closed. It is lined with hypoblast, from which is developed the epithelium of the future alimentary canal, and this hypoblast is covered externally by the visceral or splanchnic layer of the mesoblast, called the **splanchnopleure.** The primitive alimentary canal, thus composed, is separated from the body-

wall (which consists of epiblast and somatopleure) by the body-cavity or **cœlom,** and this latter subsequently becomes partitioned off into pleural, pericardial, and peritoneal cavities. The alimentary canal is closed at either end. Subsequently, however, an invagination of epiblast takes place at either end, which comes into close contact with the hypoblast forming the closed extremities, and in this way the buccal cavity at one end, and the anus and portion of the anal canal *below* the anal valves at the other end, are formed. The anterior invagination is called the **stomatodæum,** and the posterior is known as the **proctodæum.**

Stomach.—Up to the fourth week the primitive alimentary canal is very nearly a straight tube. At that period the first indication of the stomach shows itself as a somewhat spindle-shaped dilatation in the neighbourhood of the embryonic heart, this dilatation being at first practically straight. After the stomach descends into the abdominal cavity its dorsal aspect undergoes greater development than the rest of the organ, and a curve is thereby produced. The convexity of the curve at this period is directed backwards, and the concavity forwards. The surfaces of the organ are right and left respectively, and they thus naturally receive the corresponding pneumogastric nerves. The pyloric end, which at this period is directed downwards, is now tilted forwards towards the anterior abdominal wall, carrying with it the duodenum, and so giving rise to the duodenal loop. As the posterior part of the stomach continues to grow in excess of the anterior part, the organ now undergoes partial rotation towards the right side, and the upper or cardiac end is carried to the left of the middle line, thereby giving rise to the oblique position permanently assumed by the organ. The stomach, in rotating, carries with it the duodenal loop, which thus takes up a position on the right of the middle line. The original right side of the stomach now becomes the posterior surface, and the original left side becomes the anterior surface, *thus accounting for the distribution of the right pneumogastric nerve to the posterior surface in the adult, and of the left to the anterior surface.* The great curvature, which originally looked backwards, now looks downwards and to the left, and the small curvature, which originally looked towards the anterior abdominal wall, now looks upwards and to the right. These changes in the stomach take place in the course of the second month.

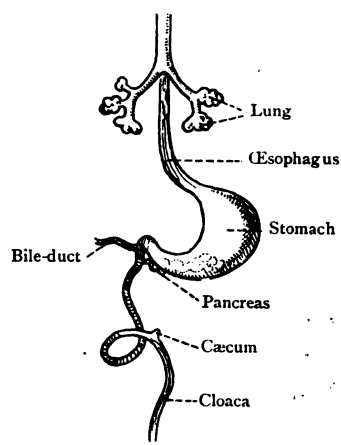


FIG. 336.—THE ALIMENTARY CANAL OF THE EMBRYO (HIS).

Intestinal Canal.—Originally there is no separation of the intestinal tube into small and large intestine. The primitive gut is at first very short and almost straight, there being a slight convexity directed towards the umbilicus. As has been stated, it communicates freely with the yolk-sac by a wide opening. When this opening becomes constricted and converted into the vitelline duct, the intestinal tube undergoes lengthening, and about the fifth or sixth week a budding or outgrowth makes its appearance, which represents the rudimentary cæcum, and is the first indication of the separation of the gut into small and large intestine. Moreover, opposite the place of attachment of the vitelline duct a somewhat horse-shoe loop (U) is formed, the duct being connected with the bend of the loop, and the rudimentary cæcum with its distal limb. This intestinal loop increases in size, and the ends of its limbs, coming together, form a neck, the upper portion of which represents the future duodenum, whilst the lower portion corresponds with the right extremity of the future transverse colon. The mesentery of the loop

contains the superior mesenteric artery. The cæcal protrusion is at first of uniform dimensions, but subsequently its blind end remains narrow so as to form the vermiform appendix, and the rest of the cæcum, together with the colon, becomes enlarged. As the small intestine grows, its mesentery does not keep pace with it, the result being that the gut is thrown into coils. The horse-shoe loop already referred to, when fully formed, attains considerable size, and at first is directed forwards in the middle line towards the anterior abdominal wall. When the coils of the small intestine become formed, they take up a position on the right side of the middle line, whilst the cæcum and colon are placed on the left side. The subsequent transposition of these parts is brought about by a rotation of the horse-shoe loop and its mesentery round an axis represented by the superior mesenteric artery, this rotation taking place from left to right. The result is as follows : (1) the cæcum and ascending colon are transferred from the left to the right side ; (2) the coils of the small intestine, together with the lower part of the duodenum, are carried from the right to the left side ; and (3) the transverse colon is shifted from below the duodenum to its anterior aspect. As regards the mesentery of the horse-shoe loop, its original right side becomes, after rotation, the left side, and its original left side becomes the right side. It is to be noted that the portion of gut representing the descending colon never changes its position from the left side.

Cæcum.—The cæcum at first lies on the left side of the middle line, just below the liver. From this position it gradually shifts to the middle line, and then to the right side, still lying just below the liver. Finally, it descends slowly to its permanent abode in the right iliac fossa, though it may be arrested at any point. The migration of the cæcum from its position below the liver on the right side to the right iliac fossa takes place somewhere between the fourth month and the period of birth, though it may be delayed to a later period.

Peritoneum.—The peritoneum is developed from the two layers into which the lateral mesoblast (lateral plate) is cleft, namely, an outer or parietal layer, which adheres to the epiblast and forms the **somatopleure,** and an inner or visceral layer, which adheres to the hypoblast and forms the **splanchnopleure,** of the *cœlom* or body-cavity.

Primitive Mesentery.—The primitive alimentary canal is originally attached to the posterior wall of the embryo in the middle line by a mesentery which extends over its whole length. This **primitive dorsal mesentery** is developed from the splanchnopleure which invests the canal, and the names of its several divisions correspond with those of the parts of the canal with which they are connected. Thus, there are the meso-gastrium, meso-duodenum, meso-jejunum, meso-ileum, and so on. In addition to the dorsal mesentery, there is a **ventral mesentery,** likewise mesoblastic, and connected with the ventral aspects of the stomach and duodenum, this latter mesentery being divided by the liver into the falciform ligament and gastro-hepatic omentum.

Changes in the Primitive Dorsal Mesentery—1. **Meso-gastrium.**—This is at first comparatively short, but it undergoes lengthening as the posterior aspect of the stomach grows, and the organ turns round on its right side. During the turning of the stomach the meso-gastrium is doubled upon itself so as to form a kind of bag directed downwards and to the left, the wall of which represents a portion of the gastro-colic omentum. The small sac of the peritoneum is in part developed within this bag, the portion so formed representing the bag or *sac of the gastro-colic omentum.* As the stomach turns round, and the gastro-hepatic omentum changes its position from antero-posterior to transverse, a part of the abdominal cavity is partitioned off behind the stomach and gastro-hepatic omentum, and in this manner the upper part of the small sac becomes formed. This part at first communicates with the rest of the abdominal cavity by a wide opening situated on the right side of the gastro-hepatic omentum. This opening, however, becomes much reduced as the liver grows, and it gives rise to the *foramen of Winslow.* The *gastro-colic omentum* is developed from the bag-like part of the meso-gastrium which grows slowly downwards and to the left over the transverse

colon, and about the fourth month becomes closely adherent to the transverse colon and its meso-colon. For the changes which subsequently take place in it, see p. 678. As regards the *gastro-splenic omentum* and *lieno-renal ligament*, the spleen is developed within the meso-gastrium, and the portion of the latter between the spleen and the stomach forms the gastro-splenic omentum, whilst the part between the spleen and the left kidney gives rise to the lieno-renal ligament.

It is to be noted that, whilst the gastro-colic omentum is developed from a part of the primitive *dorsal* mesentery, namely, the meso-gastrium, the gastro-hepatic omentum is formed by that portion of the *ventral* mesentery which extends between the liver and the stomach, the portion between the liver and the anterior abdominal wall forming the falciform ligament of the liver.

2. **Intestinal Mesenteries**—*Meso-duodenum.*—After the stomach and duodenum turn round on their right side the meso-duodenum, which is a part of the primitive dorsal mesentery, disappears by absorption. *Mesenteries of the jejunum, ileum,* and *large intestine.*—These, which are parts of the primitive dorsal mesentery, are originally continuous throughout. A change, however, takes place after the rotation of the original horse-shoe loop of the gut. The portion of mesentery within the horse-shoe loop forms the mesentery proper of the adult. The dorsal attachment of the mesentery proper is at first extremely limited, being confined to the region of the neck of the horse-shoe loop, where it extends between the duodenum above and the right extremity of the transverse colon below. This part of it contains the superior mesenteric artery, and is continuous with the mesentery of the ascending colon. As, however, development proceeds, it forms a new attachment to the posterior abdominal wall, and, as a rule, becomes cut off from the ascending meso-colon, which latter in most cases becomes removed by absorption. The transverse meso-colon remains persistent. The descending meso-colon and iliac meso-colon are, in most cases, removed by absorption, whilst the pelvic meso-colon remains persistent. The meso-rectum disappears by absorption.

Structure of the Liver.

The **liver** has two coats, external and internal. The *external* or *serous coat* is formed by the peritoneum, and is incomplete (see p. 663). Within the serous coat is the fibrous or areolar coat, which is known as the *fibrous capsule* of the organ. It is for the most part thin, except where the peritoneal coat is deficient. It is continuous all over the surface with the scanty amount of areolar tissue which pervades the interior of the organ and connects the hepatic lobules. At the portal fissure it surrounds the hepatic duct, hepatic artery, and vena portæ, under the name of the *capsule of Glisson.* The subdivisions of this capsule accompany the various branches of the duct, artery, and vein as these ramify throughout the liver in the portal canals. The liver-substance is composed of a great number of small polyhedral masses, called hepatic lobules, which are closely packed together, and are set, each by one surface, on the walls of the sublobular veins, to which they are attached by means of intralobular or central veins. In man there is very little areolar tissue between the lobules, which are therefore for the most part confluent. In some animals, however, notably the pig and camel, there is a very distinct amount of areolar tissue between the lobules, which, therefore, stand clearly apart from each other.

The average diameter of a **hepatic lobule** is $\frac{1}{20}$ inch. One of its surfaces is called the *base*. It is by this surface that the lobule is set upon the wall of a sublobular vein, and the intralobular or central vein, having emerged from the lobule through the centre of its base, opens at once into the sublobular vein. The lobules, therefore, relatively to the sublobular veins, on which they are ranged, are sessile. When a sublobular vein is opened and viewed from within, an appearance something like mosaic work presents itself, the closely-set bases of the lobules being visible through the thin wall of the vein, and the minute openings of the intralobular or central veins appearing in the centre of each base. Each lobule is composed of hepatic cells, permeated by capillary networks of blood-vessels and bile capillaries.

Bloodvessels.—The liver derives its blood from two sources, namely, the vena portæ, and the hepatic artery. These two vessels, together with the hepatic duct, are invested by the capsule of Glisson at the portal fissure. Their several branches, ensheathed by prolongations of Glisson's capsule, ramify from this point throughout the liver, being contained in the system of canals, known as **portal canals.** Each of these canals contains (1) a branch of the vena portæ, (2) a branch of the hepatic artery, accompanied by a plexus of nerves, (3) lymphatic vessels, and (4) a minute duct, all these being loosely surrounded by a prolongation of Glisson's capsule.

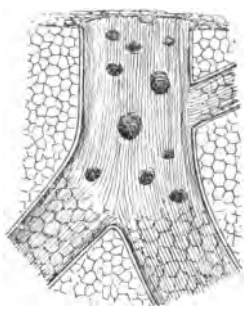


FIG. 337.—SECTION OF THE LIVER, SHOWING A LARGE HEPATIC VEIN AND ITS TRIBUTARIES (AFTER KIERNAN).

The **vena portæ** ramifies within the liver like an artery. In the portal canals its branches receive as tributaries small *capsular* and *vaginal veins*, and they go on ramifying until they arrive at the interlobular areæ. Here they anastomose freely with one another around the lobules, and so form the *interlobular plexuses*. The branches which arise from these plexuses enter the lobules on all sides except their bases, and form in the interior of each lobule an *intralobular plexus*. From this plexus a few radicles converge towards the centre of the lobule, where they form by their union the *intralobular* or *central vein*. The portal blood, though dark in colour, is very rich, being derived from, amongst other sources, the stomach and small intestine.

The **hepatic artery** is a branch of the cœliac axis. As its branches traverse the portal canals they give off *capsular branches* to the fibrous capsule of the liver, and *vaginal branches*, which supply the walls of the vessels in the portal canals, as well as their Glissonian sheaths. The branches of the artery finally end as minute *interlobular arteries*, which supply the walls of the interlobular

veins and bile-ducts. According to some authorities they send minute capillary branches into the interior of each lobule to join the intralobular plexus of the venæ portæ, but this view is not held by others.

The function of the hepatic artery and its branches is to nourish the tissues of the liver, whilst the portal blood supplies the materials which are elaborated by the hepatic cells.

The **hepatic veins** commence in the centre of each lobule as an *intralobular* or *central vein*. The intralobular veins open into the *sublobular veins*, which are closely adherent to the bases of the lobules. The sublobular veins join to form larger sublobular veins, and these in turn terminate in the *hepatic veins*, which are not in direct contact with the lobules. The hepatic veins pass to the caval fossa on the posterior surface of the liver, towards which they converge, taking up sublobular veins in their course. The passages which contain the veins are known as the **hepatic canals.** On arriving at the upper part of the caval fossa they are reduced to two or three in number, which pour their contents directly into the inferior vena cava. It is to be noted that the hepatic veins converge to the caval fissure on the posterior surface, whilst the branches of the vena portæ radiate in all directions from the portal fissure. The hepatic veins are accompanied only by lymphatic vessels, and are surrounded by a very scanty amount of areolar tissue, which explains why they present open mouths when cut across.

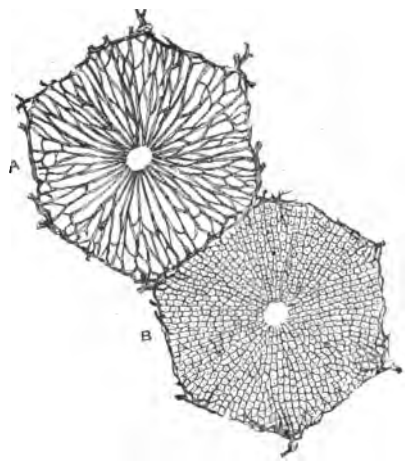


FIG. 338.—TWO HEPATIC LOBULES (HIGHLY MAGNIFIED).

A, Lobule showing the Intralobular Plexus; B, Lobule showing the Hepatic Cells.

Distinguishing Characters of the Hepatic and Portal Veins—Hepatic Veins.—(1) These present open mouths when cut across. (2) They are accompanied only by lymphatic vessels. (3) Their walls are very thin, and are practically in direct contact with the substance of the liver. (4) They converge towards the caval fossa on the posterior surface.

Portal Veins.—(1) The mouths of these veins are practically closed or collapsed when cut across. (2) The veins are accompanied by branches of the hepatic artery, and by ducts. (3) Their walls are fairly thick, and are separated from the substance of the liver by the sheaths derived from Glisson's capsule. (4) They radiate in all directions from the portal fissure in portal canals.

Hepatic Cells.—These are situated within the lobules. They are polyhedral, granular cells, having a diameter of $\frac{1}{1000}$ inch, and each contains a round nucleus. They have no cell-wall, properly

so called, and they are connected by a delicate supporting tissue. The cells, which are capable of amœboid movement, lie between, and around, the capillary vessels, where they are arranged in radiating rows converging towards the centre of the lobule.

Bile-ducts.—These commence within the lobules as *bile-capillaries* or *bile-canaliculi*, which are in reality intercellular passages. They have a very delicate wall, and are bounded on all sides by the hepatic cells—hence the name *intercellular passages*. According to Pflüger and Kupffer, the cells contain *vacuoles*, which communicate by intracellular passages with the bile-capillaries. The hepatic cells intervene between the bile-capillaries and the capillary blood-vessels. At the circumference of the lobule the bile-capillaries pass into the small *interlobular bile-ducts*. These join to form larger ducts, and these in turn go on joining until, on arriving at the portal fissure, only two ducts result, which emerge one from each lobe. These now join to form the *hepatic duct*, and this joins the cystic duct to form the common bile-duct. The walls of the interlobular ducts are very thin, being composed of a basement membrane lined with polygonal epithelium. The larger ducts in the portal canals have thicker walls, which, from without inwards, are composed of a fibro-elastic coat, containing plain muscular tissue, arranged longitudinally and circularly, and a mucous coat lined with columnar epithelium. The mucous membrane of the larger ducts presents numerous openings, which lead into blind mucus-secreting recesses. The structure of the hepatic and common bile-ducts is similar to the preceding, though on an increased scale.

Lymphatics.—These are divided into two sets, superficial and deep.

The *superficial lymphatics* form an intimate plexus beneath the peritoneum, and have different destinations. (1) Those from the mesial portions of the right and left lobes, in the vicinity of the falciform ligament, enter that ligament and pass through the diaphragm into the thorax, where they terminate in the *anterior mediastinal glands*, the efferent vessels of which pass partly to the right lymphatic duct and partly to the thoracic duct. (2) Those from the lateral parts of the supero-anterior surface and from the right lateral surface enter the right and left lateral ligaments and terminate in the *cœliac glands*. (3) Those from the uncovered area pierce the diaphragm between the two layers of the coronary ligament, and terminate in the *caval glands* in contact with the thoracic portion of the inferior vena cava, the efferent vessels of which pass to the thoracic duct. (4) A few lymphatics from the front part of the anterior surface turn round the anterior border and join the superficial lymphatics of the inferior surface, whilst others enter the liver and join the deep lymphatics. (5) The superficial lymphatics of the inferior surface for the most part pass to the portal fissure, where they meet the deep lymphatics, with which they descend between the two layers of the gastro-hepatic omentum to the *hepatic glands* therein situated, and there-

after to the *cœliac glands*. Some, however, from the back part of the inferior surface of the right lobe pass to the *lumbar glands*, whilst others from the back part of the inferior surface of the left lobe go directly to the *cœliac glands*.

The *deep lymphatics* commence in lymphatic spaces situated round the intralobular capillaries. Some of them accompany the branches of the portal vein, whilst others go with the hepatic veins. The former, on arriving at the portal fissure, meet most of the superficial lymphatics of the inferior surface, with which they descend between the two layers of the gastro-hepatic omentum to the *hepatic glands*. The latter accompany the hepatic veins to the caval fossa, and thereafter enter the thorax along with the inferior vena cava to terminate in the *caval glands*.

Nerves.—The nerves of the liver are derived from the hepatic plexus, which is an offshoot of the cœliac plexus, that in turn being derived from the solar plexus of the sympathetic system. The cœliac plexus, though principally composed of sympathetic fibres, is reinforced by a few twigs from the *right* pneumogastric nerve. The hepatic plexus accompanies the hepatic artery to the portal fissure, where it receives branches from the *left* pneumogastric nerve, which have ascended from the antero-superior surface of the stomach between the two layers of the gastro-hepatic omentum. In the liver the nerves, which are chiefly non-medullated, are distributed to the walls of the bloodvessels and ducts, penetrating as far as the interspaces between the hepatic cells.

Development of the Liver.—The liver is of *hypoblastic origin*. It makes its appearance about the second or third week in the form of a diverticulum, which springs from the ventral wall of that part of the fore-gut which forms the duodenum. This diverticulum extends into a collection of mesoblastic tissue, which lies in front of that portion of the fore-gut which gives rise to the stomach and duodenum, and is known as the *septum transversum* of His. In this septum the development of the liver proceeds in the following manner: the original diverticulum ramifies by furnishing solid buds which form columns, called *hepatic cylinders*. These cylinders, like the primitive diverticulum, give off laterally other buds, which form secondary cylinders, and so on. The primary and secondary cylinders, by branching and anastomosing freely, give rise to very intricate reticula, which intermingle with reticula of capillary bloodvessels developed in the surrounding mesoblast. The cords of these reticula give off other buds, which form fresh cylinders, and these in turn branch and anastomose, thus adding greatly to the intricacy of the reticula. The part of the fore-gut from which the primitive diverticulum springs becomes everted so as to form a kind of hollow pedicle, into which the primitive diverticulum now opens. This everted part becomes the *common bile-duct*, and the primitive diverticulum forms the *right* and *left hepatic ducts*. As the common bile-duct grows, the liver necessarily becomes shifted away from the duodenal part of the fore-gut. The branches of the ducts which lie in the future portal canals and the interlobular ducts are developed from some of the reticular cell-cylinders, which lose their solid character and become tubular. The lumen of each tube is at first surrounded by polyhedral hepatic cells, which subsequently become transformed into the columnar cells of the ducts. The cylinders which are not tunnelled into ducts give rise to the hepatic cells, which constitute the secreting part of the liver, and between these cells the bile-canaliculi are formed as passages which lead ultimately into the radicle

ducts. As the interstitial connective tissue of the liver becomes increased in amount, the organ undergoes separation into lobules. The liver, as it grows, projects from the septum transversum into the abdominal cavity, carrying with it mesoblastic tissue which forms the ventral mesentery, and the portion of the septum transversum which is left behind forms the principal part of the diaphragm. The part of the ventral mesentery which extends between the liver and the anterior abdominal wall forms the falciform ligament, and the part which extends from the liver to the ventral aspect (subsequently the small curvature) of the stomach forms the gastro-hepatic omentum.

The capillary networks, which intermingle with the reticula formed by the cell-cylinders, become connected, on the one hand, with branches of the embryonic vitelline veins, called *venæ advehentes*, which give rise to the branches of the vena portæ, and, on the other hand, with vessels, called *venæ revehentes*, which give rise to the hepatic veins. The connective tissue of the liver is developed from the mesoblast.

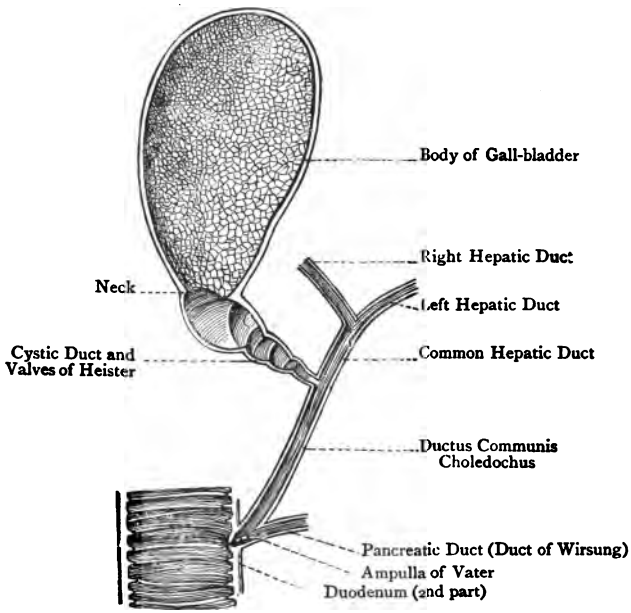


FIG. 339.—THE EXCRETORY APPARATUS OF THE LIVER.

Structure of the Gall-bladder.—The wall of the gall-bladder is composed of three coats—serous, fibro-muscular, and mucous.

The **serous coat** is formed by the peritoneum, and is usually incomplete, being confined to the inferior and lateral surfaces. Sometimes, however, the peritoneum completely surrounds the organ, and attaches its superior surface to the cystic fossa of the liver by a ligamentous fold.

The **fibro-muscular coat** is composed of fibrous and plain muscular tissues. The fibrous bands are disposed in all directions, and interlace freely with one another. The muscular fibres, which inter-

mingle with the fibrous bands, are arranged both longitudinally and transversely.

The **mucous coat** is covered by columnar epithelium. Its surface presents a great number of small ridges, which interlace in all directions and enclose polygonal depressions or alveoli of various sizes. This pitted appearance bears a resemblance to honeycomb, and the mucous membrane of the vesiculæ seminales in the male is similarly arranged. The mucous coat is richly provided with mucous glands. In the neck of the gall-bladder, which describes two curves like the letter **S**, there are two fibro-mucous folds, which project into the interior, one opposite each curve, and serve as valves.

Structure of the Cystic Duct.—The wall of the duct is composed of a fibro-elastic and muscular coat, and a mucous coat. The former resembles that of the gall-bladder. The mucous coat, which is covered by columnar epithelium, presents several crescentic folds, disposed obliquely round the wall in a spiral or somewhat corkscrew manner, and succeeding each other at frequent intervals. When the duct is distended, its exterior presents a series of spiral constrictions with intervening swellings. The spiral folds in the interior serve as valves, which are known as the *valves of Heister*, or of *Amussat*.

Blood-supply.—The gall-bladder is supplied by the **cystic artery**, which is a branch of the right division of the hepatic. Its course is forwards between the hepatic and cystic ducts to the neck of the organ, where it divides into two branches, superior and inferior. The *superior branch* ramifies on the upper surface of the organ, between it and the cystic fossa of the liver, whilst the *inferior branch* is distributed over the inferior surface beneath the peritoneum. The **cystic vein**, which is formed by the union of superior and inferior branches, usually opens into the *right division* of the vena portæ.

Lymphatics.—These pass between the two layers of the gastro-hepatic omentum to the *hepatic glands*.

Nerves.—These are derived from the hepatic sympathetic plexus.

Development of the Gall-bladder and Cystic Duct.—These are formed in the course of the second month as a diverticulum from the common bile-duct.

Structure of the Pancreas.

The pancreas belongs to the class of compound racemose or acino-tubular glands, and bears a close resemblance to a serous or true salivary gland, *e.g.*, the parotid. It has a greyish-pink colour, and is somewhat soft in consistence. It is from 6 to 8 inches long, from 1 to 1½ inches deep, except at the right and left extremities, and from ½ to ¾ inch thick. Its weight is about 3½ ounces. It is destitute of a fibrous capsule, properly so called, and is invested merely by a thin connective-tissue covering, which readily allows the outline of the lobules to be seen.

It is composed of a number of lobules, which are loosely held together by ducts and areolar tissue. Each **lobule** consists of a group of alveoli or acini which are long, tubular, and convoluted, wherein they differ from the saccular alveoli of such a gland as the parotid. From each lobule a duct passes off, which unites with the ducts of adjacent lobules in the left extremity of the gland to form the commencement of the principal duct.

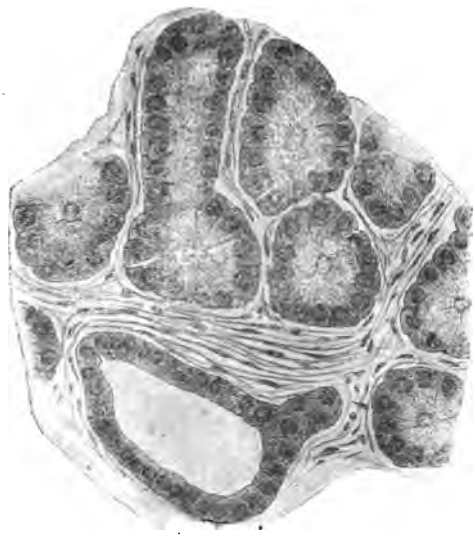


FIG. 340.—STRUCTURE OF THE PANCREAS (HIGHLY MAGNIFIED).

The **alveoli** or **acini** are each composed of a basement membrane, reticular in structure, and lined with columnar epithelium, the basement membrane being continuous with the wall of the duct. The lumen of each acinus is small, and is usually occupied by spindle-shaped cells, known as the *centro-acinar cells of Langerhans*, which are continuous with the cells of the junctional duct. The connective tissue which covers the pancreas sends expansions inwards between the lobules, along which the bloodvessels are conducted. Further, the interlobular connective tissue penetrates into the lobules, and so conducts the bloodvessels into their interior. The *interalveolar* connective tissue has a loose disposition, and in certain parts contains isolated groups of epithelium-like cells, surrounded by large convoluted capillary vessels. These groups constitute the **islets of Langerhans,** which are characteristic of the pancreas.

Excretory Apparatus of the Pancreas.—There is one principal duct, called the **pancreatic duct** or **duct of Wirsung.** It is buried in the substance of the gland, and is readily recognised by its white colour. It lies nearer the posterior than the anterior surface, and rather nearer the lower than the upper part of the gland. It commences in the tail, whence it runs through the body as far as the neck, receiving in its course a great many tributaries. On arriving at the neck it gets a branch from the accessory pancreatic duct, and then it describes a bend, and passes into the head in a direction downwards, backwards, and to the right. Finally, on leaving the pancreas it meets with the common bile-duct, and the two, entering the wall of the second part of the duodenum, terminate in the manner already described (see p. 665).

The **accessory pancreatic duct** or **duct of Santorini** is comparatively small, and varies much in size. If well developed, it commences in the lower part of the head, where it takes up the ducts of the lobules of that part. It then passes upwards with an inclination to the right, and divides into two branches. One of

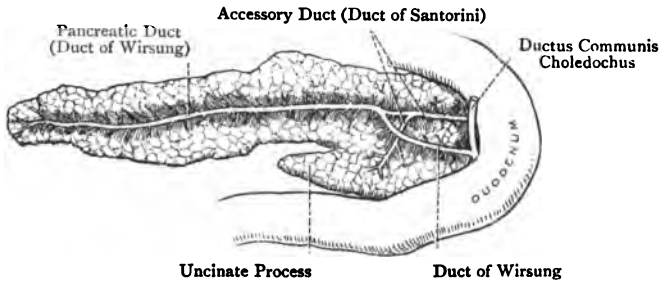


FIG. 341.—THE PANCREAS AND ITS DUCTS (POSTERIOR VIEW).

these joins the duct of Wirsung in the neck, whilst the other opens into the second part of the duodenum at a point about 1 inch above the common opening of the common bile-duct and duct of Wirsung. The secretion conveyed by the duct of Santorini in early life is usually regarded as flowing into the duodenum, whilst in the adult it is diverted into the duct of Wirsung.

The tributaries of the principal duct, as well as of the accessory duct, when followed into the pancreas, become in succession *interlobular* and *intralobular ducts*. The intralobular ducts pass within the lobules, and end in *intermediary*, *junctional*, or *intercalary** *ducts*, with which the alveoli or acini are directly connected. The part of the duct between the intermediary and the intralobular duct is called the *neck*. The walls of the intermediary ducts are thin, and are formed of a basement membrane covered by flattened epithelial cells, the neck being lined by polyhedral cells. In the larger ducts a connective-tissue coat is superadded to the basement membrane, which is now covered by columnar epithelium. The duct of Wirsung, though of comparatively large size, has a thin wall destitute of muscular fibres, and composed of two coats—external fibrous and internal mucous. The mucous coat is smooth and covered by columnar epithelium.

Varieties—(1) **Small Pancreas.**—This consists in a permanent detachment of the unciform process, or that part of the pancreas which extends along the upper aspect of the third part of the duodenum and has the superior mesenteric vessels in front of it. (2) The head of the pancreas may surround the second part of the duodenum more or less completely. (3) **Accessory Pancreas.** When an accessory pancreas is present it is usually met with in the wall of the upper part of the duodenum, but it may be found in the wall of the stomach. (4) The duct of Wirsung sometimes opens into the duodenum independently of, but close to, the common bile-duct.

* Interposed or inserted between the alveoli and the intralobular ducts.

Blood-supply.—The pancreas derives its **arteries** from (1) the pancreatic branches of the splenic artery, one of which accompanies the principal duct from left to right, and is known as the *arteria pancreatic magna;* (2) the superior pancreatico-duodenal of the gastro-duodenal from the hepatic; and (3) the inferior pancreatico-duodenal of the superior mesenteric.

The **veins** are (1) the pancreatic veins, which open into the splenic vein, and (2) the pancreatico-duodenal vein, which terminates in the superior mesenteric vein. All the pancreatic venous blood eventually passes into the portal vein.

Lymphatics.—These commence as lymphatic clefts around the alveoli, and pass chiefly to the *cœliac glands*. Some of them, however, terminate first in the superior mesenteric glands in contact with the upper part of the superior mesenteric artery.

Nerves.—These are derived from offshoots of the hepatic, splenic, and superior mesenteric plexuses, and accompany the arteries. They are chiefly composed of non-medullated fibres.

Development of the Pancreas.—The pancreas is of *hypoblastic origin*. It makes its appearance in the form of two diverticula, one of which springs from the dorsal aspect, and the other from the ventral aspect, of the duodenal portion of the fore-gut, the latter lying close to the hepatic diverticula. The great bulk of the organ is developed from the *dorsal diverticulum*. These diverticula give off laterally hollow offshoots; these in turn give off other hollow offshoots, and so on until, by this ramifying process of sprouting, an acino-tubular gland is built up. The terminal offshoots form the alveoli or acini, whilst the other offshoots form the ducts. The two primary diverticula, though originally separate, unite in the course of the second month. The principal duct is at first connected with the dorsal diverticulum. As development proceeds, the duodenal part of this diverticulum does not keep pace in growth with the ventral diverticulum, and it consequently persists in a vestigial form, under the name of the accessory pancreatic duct or duct of Santorini. The ventral diverticulum exhibits greater growth, and the principal duct of the pancreas (duct of Wirsung), which originally is continuous with the dorsal diverticulum, is now apparently continued into the ventral diverticulum. Eventually the two ducts open separately on the inner and posterior aspect of the bowel, the explanation being that the duodenum, along with the stomach, turns round on its right side, its walls at the same time undergoing disproportionate growth. The ventral diverticulum joins, in most cases, the common bile-duct in the wall of the bowel, though it may open by an independent orifice. The further development of the pancreas takes place between the two layers of the mesogastrium, so that at first it is completely invested by peritoneum, and it occupies a mesial position. When, however, the stomach and duodenum undergo rotation towards the right, the pancreas also turns over on its right side, and then comes to lie across the posterior wall of the abdomen, the peritoneum covering its posterior surface being removed by absorption.

Structure of the Spleen.

The spleen is the largest ductless gland in the body. It has two coats, serous and fibrous, inseparably connected together. The *serous coat* is formed by the peritoneum. The *fibrous coat* or *tunica propria* is composed of fibrous tissue, with a considerable admixture of elastic tissue, and a certain amount of

plain muscular tissue, all of which build up a strong distensible tunic.

The organ is composed of a trabecular network, the spleen pulp, bloodvessels, and Malpighian corpuscles.

The tunica propria sends into the organ a number of trabeculæ which, like the tunica propria, are composed of fibrous, elastic, and plain muscular tissues. These divide and subdivide, and unite with one another, as well as with processes derived from the sheaths which the bloodvessels carry in with them at the hilum. There is thus formed a **trabecular network** which pervades the interior, and contains in its meshes the spleen pulp, capillary tufts, and Malpighian corpuscles.

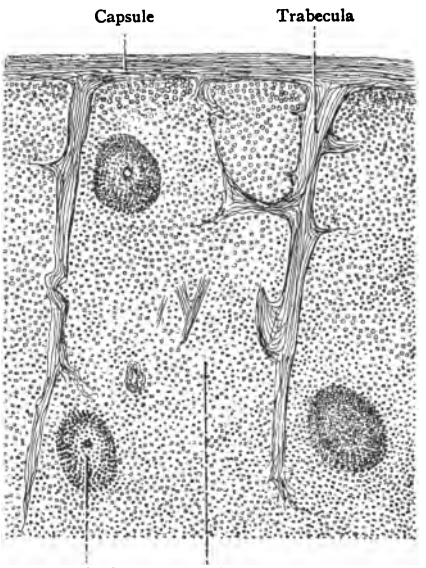


FIG. 342.—SECTION OF THE SPLEEN.

The **spleen pulp** occupies the meshes of the network formed by the trabeculæ. It is soft, and has a dark red colour, which, however, becomes brighter on exposure to the air. The matrix of the spleen pulp is reticular, and is formed by branched connective-tissue corpuscles, which constitute the *sustentacular cells* of the organ. The matrix is, therefore, in reality retiform tissue. The interstices of the reticulum contain blood, in which there is a large number of white corpuscles, and also special cells characteristic of the spleen, and called the *splenic cells*. These latter are of large size, and are amœboid. They contain pigment, and red blood-corpuscles in various stages of disintegration.

Bloodvessels and Malpighian Corpuscles—Arteries.—The splenic artery furnishes five or six large branches which enter the organ at the hilum, and carry in with them trabecular sheaths from the tunica propria. In the interior they divide and subdivide, and finally terminate in pencil-like clusters of capillary vessels, by which time they have laid aside all their coats except the endothelial lining. The endothelial cells then become separated from each other by spaces, and, being continuous with the sustentacular cells of the spleen pulp, the blood flows directly into the interstices of the reticulum of the pulp. The arteries, which are at first accompanied by trabecular sheaths, ultimately lose these sheaths, and

enter the spleen pulp to end in clusters of capillaries. Before they terminate in these clusters their external coat undergoes an important modification, which consists in its transformation into lymphoid or adenoid tissue. This lymphoid tissue forms at intervals small round or oval enlargements, called the **Malpighian corpuscles,** which on section appear as minute white specks in the dark red spleen pulp. These corpuscles are simply localized expansions of the lymphoid tissue which forms the external coat of the small arteries. The expansion may be confined to one side of the artery, or it may include the whole of its circumference. Each corpuscle receives minute twigs from the artery on which it is set, and contains large numbers of lymph corpuscles, as well as capillary bloodvessels.

Veins.—The arterial blood, on leaving the capillary vessels, flows directly into the interstices of the reticular matrix of the spleen pulp, and from these it is taken up by radicle veins which commence in a manner similar to that in which the capillaries end. Endothelial cells, continuous with the sustentacular cells of the pulp, come together and cohere, so as to form very delicate tubular vessels, having closed walls. As these radicle veins unite and become larger the usual other coats are superadded to the endothelial lining. Ultimately five or six veins leave the spleen at the hilum, which unite to form the splenic vein, this in turn uniting with the superior mesenteric vein to form the vena portæ.

It is to be noted that, in the circulation through the spleen, the arterial blood leaves tubular vessels and flows through the interstices of the reticulum of the spleen pulp, where it bathes the Malpighian corpuscles, after which it enters tubular vessels of the nature of veins.

The **cells of the spleen** are of three kinds as follows: (1) the sustentacular cells of the retiform tissue of the spleen pulp; (2) the splenic cells; and (3) lymphoid corpuscles.

Lymphatics.—These are arranged in two groups—trabecular and perivascular. The *trabecular lymphatics* are contained in the trabeculæ, and communicate with a lymphatic network in the tunica propria underneath the peritoneal coat. The *perivascular lymphatics* commence in the lymphoid tissue which forms the external coat of the smaller arteries. At the hilum both sets of lymphatics meet and pass to the *splenic glands*, and thence to the *cœliac glands*.

Nerves.—These are derived from the splenic plexus, which is an offshoot from the cœliac plexus of the solar plexus. The fibres, which are mostly non-medullated, are derived partly from the sympathetic system and partly from the right pneumogastric nerve.

Development of the Spleen.—The spleen is developed within the mesogastrium in close relation with the pancreas, but, whilst the pancreas is of *hypoblastic* origin, the spleen is developed from the *mesoblast*. It first makes its appearance in the second month, at which period the mesoblastic tissue becomes permeated by bloodvessels; but this takes place slowly, and the

Malpighian corpuscles are the last constituent elements to be formed. In its growth towards the left side the spleen carries with it the left layer of the mesogastrium, and from this there are formed the gastro-splenic omentum and lieno-renal ligament.

Structure of the Suprarenal Capsules.

The **suprarenal capsules** or **bodies** (*adrenals*) belong to the so-called ductless glands. Each capsule is enclosed in a thin sheath of connective tissue, from the deep part of which processes are given off into the interior, where they form a supporting stroma. The proper substance of the capsule is divided into an external or cortical, and internal or medullary part.

The **cortical part** has a somewhat yellowish tint, and is composed of cells supported by a fibrous stroma. The cells being variously arranged in different parts, the cortex is divisible into three zones, named, from without inwards, zona glomerulosa, zona fasciculata, and zona reticularis. The **zona glomerulosa,** which is narrow, lies immediately within the external capsule, and is so named because its component cells are grouped in such a manner as to form glomeruli, which are embedded in a fibrous stroma. The cells are polyhedral, and each contains a clear round nucleus. The **zona fasciculata** forms the chief part of the cortex, and is so named because its component cells are arranged in columns or fasciculi. The cells are similar to those of the zona glomerulosa, and the cell-columns are separated from one another by fibrous trabeculæ, which act as carriers of the bloodvessels, nerves, and lymphatics. The **zona reticularis,** which is narrow, lies within the zona fasciculata, and is so named because its component groups of polyhedral cells are connected with one another in such a manner as to form a reticulum.

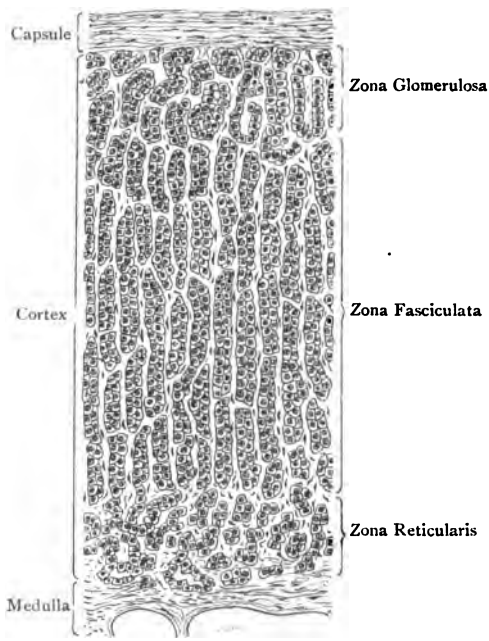


FIG. 343.—SECTION OF THE SUPRARENAL CAPSULE.

The **medullary part** is confined to the centre of the capsule in the adult, is soft in consistence, and has a reddish-brown colour, due to the contained venous blood. The supporting fibrous stroma of the cortex pervades it, and is arranged in a reticular manner. The meshes of this reticulum are occupied by cells, resembling somewhat epithelial cells, and larger and more irregular than those of the cortex, some of them being branched.

Blood-supply—Arteries.—These are (1) the superior capsular of the inferior phrenic or diaphragmatic from the abdominal aorta, (2) the middle capsular from the abdominal aorta, and (3) the inferior capsular from the renal.

The **veins** of each capsule eventually unite to form one suprarenal vein. This vessel emerges through the hilum, and on the *right* side it opens directly into the inferior vena cava, whilst on the *left* side it terminates in the left renal vein.

The **lymphatics** terminate in the *median lumbar glands*.

Nerves.—The suprarenal capsules are very richly supplied with nerves, which are derived from (1) the inferior or diaphragmatic plexus from the semilunar ganglion of the solar plexus, (2) the suprarenal plexus from the semilunar ganglion and cœliac plexus, and (3) offshoots from the renal plexus. According to Bergmann the suprarenal capsules also receive fibres from the phrenic and pneumogastric nerves. The fibres, which are chiefly non-medullated, form rich plexuses in the medullary part, where they have numerous ganglion cells connected with them.

Development of the Suprarenal Capsules—Cortex.—The cortical part is of *mesoblastic origin*. According to some authorities its cells are derived from the cellular columns of the capillary tufts (Malpighian corpuscles) of the Wolffian body, but according to others the cells are derived from the germinal epithelium. **Medulla.** — According to one view the medullary part is developed from cells which grow out from the cellular column representing the rudimentary sympathetic cord and become invested by the cortex. The other view is that the cells of the medulla are derived from those of the cortex.

Structure of the Kidneys.

The kidneys are compound tubular glands. Each organ is invested by a capsule, composed of fibrous tissue with a certain amount of elastic fibres. The deep surface of this capsule is attached to the peripheral portion of the renal substance by fine fibrous processes and small bloodvessels. Underneath it there is a certain amount of plain muscular fibre-cells, arranged in a somewhat plexiform manner. At the hilum on the inner border it is prolonged inwards to line a cavity to which the hilum leads, called the *sinus*, where it becomes continuous with the fibrous coats of the calices.

When a kidney is cut into two halves by a longitudinal incision carried from the outer to the inner border, it is seen to be composed of two parts—cortical and medullary.

The *medullary part*, which is internal in position, is arranged in

conical bundles, termed the *pyramids of Malpighi*, which vary in number from eight to eighteen, the average number being about twelve. The bases of these pyramids are directed towards the circumference, whilst their apical parts, called *papillæ*, project into the sinus, where they are grasped by the calices. Each Malpighian pyramid is divided into three parts, namely, the *boundary zone* or *basal part*, the *papillary zone*, and the *apex*. The boundary zones of the pyramids form collectively the *boundary* or *intermediate layer* of the kidney. They abut against the cortical substance, which sends prolongations between them, called *septula renum* or

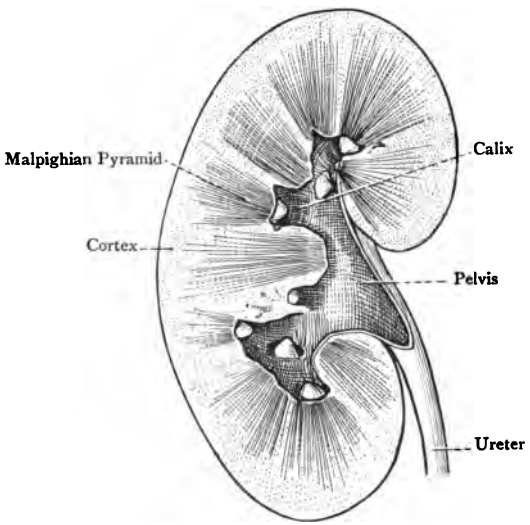


FIG. 344.—DIAGRAM OF THE KIDNEY IN LONGITUDINAL SECTION.

columnæ Bertini. These prolongations extend as far as the commencement of the apical parts of the papillary zones, where they cease, so that these apical parts project into the calices free from cortical investments. Each Malpighian pyramid is composed of straight, slightly diverging uriniferous tubules (*tubuli recti*) and straight bloodvessels, the number of tubules being very much greater in the boundary zone or basal part than elsewhere. This straight arrangement of tubules and bloodvessels imparts to each pyramid a longitudinally striated appearance from apex to base. The boundary zones or basal parts have a dark reddish-brown colour, which becomes brighter in the papillary zones.

The *cortical part* of the kidney is mainly situated within the fibrous capsule. It has a reddish-brown colour and, as already stated, sends prolongations between the Malpighian pyramids. Like the medullary part, it is composed of uriniferous tubules and bloodvessels, but the tubules are principally convoluted (*tubuli*

contorti), though there are also bundles of straight tubules (*tubuli recti*) which have issued from the Malpighian pyramids, and form the *medullary rays* or *pyramids of Ferrein*.

Cortex.—The cortical part is composed of the labyrinth and the medullary rays or pyramids of Ferrein.

Labyrinth.—This portion of the cortex is so named from the very complicated arrangement of its tubules. It is situated in the interspaces between the medullary rays, and is composed of convoluted uriniferous tubules, bloodvessels, and Malpighian corpuscles, each of which corpuscles is enclosed within a capsule of Bowman.

Uriniferous Tubules.—Each tubule commences in the labyrinth of the cortex in a spherical dilatation, called the *capsule of Bowman*, within which there is a tuft of convoluted capillary bloodvessels, known as a *glomerulus* (Ruysch) or *Malpighian corpuscle*. Bowman's capsule presents two poles. One of these is formed by two bloodvessels, afferent and efferent, which pierce the capsule at separate points, but close to each other. At the other pole Bowman's capsule becomes constricted, and forms the **neck** of a cylindrical tubule. After the tubule has passed the neck it becomes convoluted, and forms the *first* or *proximal convoluted tubule*. The basement membrane and lining epithelium of Bowman's capsule are continuous with the basement membrane and lining epithelium of the proximal convoluted tubule, and the space between Bowman's capsule and the glomerulus is continuous with the lumen of the tubule. The proximal convoluted tubule soon becomes straight, though slightly wavy, and, entering a medullary ray, it forms the *spiral tubule*. This tubule, on reaching the junction of the cortex and boundary layer, becomes suddenly very narrow, and traverses the boundary zone of a Malpighian pyramid. It is known as the *descending tubule of Henle*. On leaving the boundary zone it enters the papillary zone, and after a short course it describes a very sharp bend, called the *loop of Henle's tubule*. It now retraces its steps from the papillary zone into the boundary zone of a Malpighian pyramid, in which latter situation it becomes suddenly enlarged. This part, which retraces its steps, is called the *ascending tubule of Henle*. It re-enters the cortex, where it becomes narrower, and passes into a medullary ray, in which it lies for a short distance. It subsequently, however, leaves the ray, and, entering the labyrinth, winds between the convoluted tubules as the *irregular* or *zigzag tubule*, which has become slightly enlarged. This zigzag tubule then passes into the *second* or *distal convoluted* (*intercalary*) *tubule*. This tubule, becoming narrow, passes into the *junctional* or *collecting tubule*, which is slightly wavy. The junctional tubule leads into the *straight collecting tubule* which is slightly enlarged, and is situated in a medullary ray. This straight collecting tubule now passes to the boundary zone of a Malpighian pyramid, taking up in its course other junctional tubules from the labyrinth. In passing through the various parts of a Malpighian pyramid the straight collecting tubules unite at

acute angles, and so become less numerous and at the same time larger. They run in straight, slightly converging lines towards the apex of a papilla, where they are very much reduced in numbers,

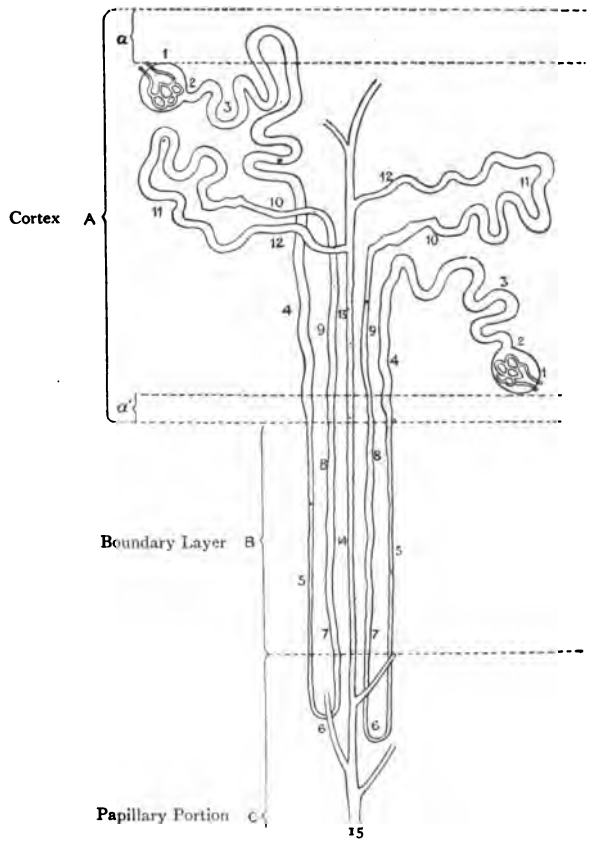


FIG. 345.—DIAGRAM OF THE URINIFEROUS TUBULES OF THE KIDNEY (KLEIN).

a and *a'*, Outer and Inner Zones of Cortex, which are free from Malpighian Corpuscles.

1. 1. Capsule of Bowman
2. 2. Neck of Capsule
3. 3. Proximal Convoluted Tubule
4. 4. Spiral Tubule
5. 5. Descending Limb of Henle's Loop
6. 6. Loop of Henle
7. 7., 8. 8., 9. 9., Ascending Limb of Henle's Loop
10. 10. Irregular Tubule
11. 11. Distal Convoluted Tubule
12. 12. Junctional Tubule
13., 14. Straight Collecting Tubule
15. Excretory Tube or Duct of Bellini

but of large size. In this final part of their course each straight collecting tubule forms the *excretory tube* or *duct of Bellini*. These excretory tubes open on the apex of a papilla, where there is often

a *foveola* or small depression, and through these openings the urine escapes into a calix.

The diameter of the excretory tubes or ducts of Bellini is about the $\frac{1}{200}$ inch.

Summary of a Tubule from Beginning to End.

1. The **capsule of Bowman,** containing a glomerulus or Malpighian corpuscle, in the *labyrinth.*
2. The **neck,** in the *labyrinth.*
3. The **first** or **proximal convoluted tubule,** in the *labyrinth.*
4. The **spiral tubule,** in a *medullary ray.*
5. The **descending tubule of Henle** (small), in a *boundary zone,* and in *part of a papillary zone,* of a *Malpighian pyramid.*
6. The **loop of Henle's tubule,** in a *papillary zone.*
7. The **ascending tubule of Henle** (large), in *part of a papillary zone,* a *boundary zone,* and the *cortex,* in which latter it is in a *medullary ray.*
8. The **irregular** or **zigzag tubule,** in the *labyrinth.*
9. The **second** or **distal convoluted (intercalary) tubule,** in the *labyrinth.*
10. The **junctional tubule,** in the *labyrinth* on its way to a medullary ray.
11. The **straight collecting tubule,** in a *medullary ray* of the *cortex,* and in a *boundary zone* of a *Malpighian pyramid.*
12. The **excretory tube,** or **duct of Bellini,** in a *papillary zone* of a *Malpighian pyramid.*

Structure of the Uriniferous Tubules.—The tubules are composed of a basement membrane lined with a single layer of epithelial cells. The basement membrane itself consists of flattened epithelial cells. The tubules vary in size, but their average diameter may be stated as $\frac{1}{1\,6\,0}$ inch. The characters of the lining epithelial cells present differences in the different tubules, which will now be considered in order.

1. The **capsule of Bowman** is lined with a single layer of *flattened epithelium,* which is reflected over the glomerulus or Malpighian corpuscle, where it is more distinct in early life than in the adult.
2. The **neck** is lined with *cubical epithelium.*
3. The **first** or **proximal convoluted tubule** is also lined with *cubical epithelium,* but the cells, which are thick, are peculiar. The inner part of each cell—that is the part next the lumen of the tubule, including the spherical nucleus, has *granular* protoplasm, whilst the outer part—that is, the part next the basement membrane—has its protoplasm *striated* or *fibrillated,* owing to the presence of rod-shaped fibrils disposed vertically to the basement membrane (Heidenhain). These fibrillated cells are provided laterally with processes, by which they embrace one another. The lumen of the tubule is distinct.
4. The **spiral tubule** is lined with epithelium similar to that of the proximal convoluted tubule, and its lumen is distinct.
5. The **descending tubule of Henle** is lined with clear, thin, *flattened cells.* The tubule, though narrow, has a distinct lumen.
6. The **loop of Henle's tubule** is lined with epithelium which resembles that of the descending tubule.
7. The **ascending tubule of Henle** is lined with *fibrillated, cubical epithelial cells* like those of the proximal convoluted and spiral tubules. Though it is of comparatively large size, its lumen is small.
8. The **irregular** or **zigzag tubule** is lined with *cubical epithelial cells,* which are markedly fibrillated, and its lumen is minute.
9. The **second** or **distal convoluted tubule** is lined with epithelium which resembles that of the proximal convoluted tubule, with the following differences: (*a*) the cells are longer; and (*b*) they are highly refractive. In size it corresponds with the proximal convoluted tubule.
10. The **junctional tubule** is lined with clear *flattened, cubical epithelial cells,* and its lumen is large.

11. The **straight collecting tubule** is lined with epithelial cells, which, in its earlier part, are clear and *cubical*, but in its later part they are *columnar*, and the lumen is very distinct.

12. The **excretory tube** or **duct of Bellini** is lined with epithelial cells which are clear and *columnar*.

Medullary Rays or *Pyramids of Ferrein.*—These take the form of pyramidal bundles of uriniferous tubules, which are separated from each other by portions of the labyrinth. The tubules are straight, and emerge from the boundary zones of the Malpighian pyramids. As these medullary rays are followed from the boundary zones to the periphery, each gradually diminishes in breadth, and ultimately tapers to a point, which stops a short distance from the fibrous capsule, being separated from it by a portion of the labyrinth. The rays are thus conical, their bases being at the boundary zones of the Malpighian pyramids, and their apices near the fibrous capsule—hence the name 'pyramids.' The explanation of this shape is that the tubules at the circumference of a medullary ray enter the labyrinth sooner than those in the centre, which latter form the apex of the ray.

Summary of a Medullary Ray.—Each contains the following tubules: (1) spiral tubules; (2) ascending tubules of Henle; and (3) straight collecting tubules.

Medulla of the Kidney.—The medullary portion has been already generally described. It is composed of Malpighian pyramids, consisting of uriniferous tubules and bloodvessels (true and false).

The tubules in the various parts of the Malpighian pyramids are as follows:

1. *Boundary Zone.*—This contains the following tubules:
   Portions of the **descending tubules of Henle.**
   Portions of the **ascending tubules of Henle.**
   Straight collecting tubules.
2. *Papillary Zone.*—This contains the following tubules:
   Portions of the **descending tubules of Henle.**
   The **loops of Henle's tubules.**
   Portions of the **ascending tubules of Henle.**
   The **excretory tubes** or **ducts of Bellini.**
3. *Apex of the Papillary Zone.*—This contains only the **excretory tubes** or **ducts of Bellini.**

Bloodvessels of the Kidneys—Arteries.—Each kidney receives a large amount of blood from the renal artery, which is a branch of the abdominal aorta. This vessel, as it approaches the hilum, divides into four or five branches, which enter the sinus, where they are embedded in fat along with the calices. They then subdivide into **interlobar branches,** which pass between the Malpighian pyramids, where they continue to subdivide. On arriving at the junction of the cortex and boundary layer they form a series of arches, which are independent of one another, and are called the **cortico-medullary arches.** Alongside of these there are venous arches, which, unlike the arterial arches, anastomose freely with

one another. The convexities of the incomplete arterial arches are directed towards the cortex, and the concavities towards the Malpighian pyramids. The branches of the arches are interlobular and arteriæ rectæ.

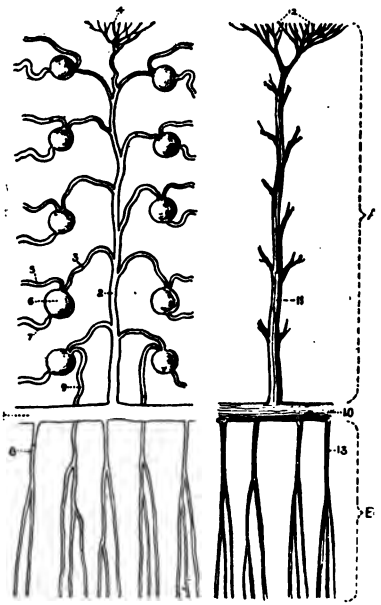


FIG. 346.—DIAGRAM OF THE BLOOD-VESSELS OF THE KIDNEY.

A, Cortex; B, Medulla.

1. Arterial Arch
2. Interlobular Artery
3. Afferent Artery of Glomerulus
4. Capsular Branches
5. Efferent Vessel of Glomerulus
6. Malpighian Corpuscle
7. Proximal Convoluted Tubule
8. True Arteria Recta
9. False Arteria Recta
10. Venous Arch
11. Interlobular Vein
12. Venæ Stellatæ
13. Venæ Rectæ

The **interlobular arteries** (cortical) arise from the convexities of the arches and enter the labyrinth of the cortex, in which they pass outwards between the medullary rays. They give off afferent and capsular branches.

The *afferent branches* are so named because they carry blood to the glomeruli or Malpighian corpuscles. They arise from the interlobular arteries at frequent intervals, and each passes to a capsule of Bowman without giving off any branch. Having pierced the capsule at one pole, the afferent vessel breaks up into a number of convoluted capillary vessels, which form a small vascular ball, called a **glomerulus** or **Malpighian corpuscle.** The blood is conveyed away from the glomerulus by an *efferent vessel*, which is variously regarded as an artery and a vein. This efferent vessel is smaller than the afferent artery. It pierces Bowman's capsule at the same pole as the afferent artery, but separate from, though close to, it. Thereafter it breaks up into a network of capillary vessels, which invest the corresponding proximal convoluted uriniferous tubule, the meshes of the network being polygonal. The efferent vessels of those glomeruli which lie nearest to the Malpighian pyramids are disposed in a different manner. They break up into bundles of straight vessels, called *false vasa recta*, which enter the boundary zones or basal parts of the pyramids, where they supply to a large extent the uriniferous tubules, upon the walls of which they form capillary networks with elongated meshes. It is, however, to be noted that the Malpighian pyramids also receive true arteriæ rectæ from the cortico-medullary arterial arches.

Malpighian Corpuscles.—A Malpighian corpuscle of the kidney is a **glomerulus** or small ball of convoluted capillary bloodvessels, having two vessels connected with it, one of which is an afferent artery and the other an efferent vessel. The vessels of many of the corpuscles are collected into bundles, an arrangement which renders these corpuscles lobulated, the number of lobules varying from two to five. Each corpuscle lies within a capsule of Bowman, and the flattened epithelium of the capsule is reflected over the corpuscle from the points of entrance and exit of the afferent and efferent vessels. The epithelial cells covering the corpuscle are thicker and less flattened than those lining the capsule of Bowman, and are better marked in early life than in the adult. In the case of the lobulated corpuscles the epithelial investment dips in between the component lobules. The epithelium of Bowman's capsule and the epithelium of the corpuscle, which in each case forms a single layer, are separated from one another by a slight interspace. The diameter of a Malpighian corpuscle is about $\frac{1}{200}$ inch. The corpuscles are confined to the cortex of the kidney, where they lie in rows in the labyrinth between the medullary rays. There is a narrow zone immediately within the external capsule, and another narrow zone close to the Malpighian pyramids, from both of which Malpighian corpuscles are absent.

FIG. 347.—DIAGRAM SHOWING A MALPIGHIAN CORPUSCLE OF THE KIDNEY WITH ITS AFFERENT AND EFFERENT VESSELS, AND A PROXIMAL CONVOLUTED TUBULE WITH ITS VENOUS PLEXUS (BOWMAN).

1. Glomerulus
2. Bowman's Capsule
3. Uriniferous Tubule
4. Interlobular Artery
5. Afferent Vessel
6. Efferent Vessel
7. Venous Plexus around Tubule
8. Interlobular Vein

The *capsular branches* of the interlobular arteries supply the external fibrous capsule of the kidney, in which they anastomose with branches of the lumbar arteries from the abdominal aorta.

The **arteriæ rectæ** (medullary), or vasa recta (true), arise from the concavities of the cortico-medullary arterial arches, and at once enter the boundary zones or basal parts of the Malpighian pyramids. Here they break up into bundles of straight, slightly diverging arterioles, which run between the bundles of straight, slightly converging uriniferous tubules, a mutual arrangement which imparts to the Malpighian pyramids a longitudinally-striated appearance. The capillary networks formed by these arterioles have necessarily elongated meshes. It is to be noted that the Malpighian pyramids derive their blood-supply from two sources, namely, (1) the arteriæ rectæ, or vasa recta (true), from the cortico-medullary arterial arches, and (2) the false vasa recta from the efferent vessels of those glomeruli which lie nearest the Malpighian pyramids. It is also to be noted that a Malpighian corpuscle of

the kidney is a ball of convoluted capillary bloodvessels, which is enclosed within a capsule of Bowman, whereas a Malpighian corpuscle of the spleen is a collection of lymphoid or adenoid tissue which is a localized expansion of the external or lymphoid coat of the small arteries in the interior of that organ.

Veins—*Veins of the Cortex.*—These are called the *interlobular veins.* Some of them commence on the surface of the kidney beneath the capsule, from which they return blood, and these are called *venæ stellatæ,* because the venous radicles which give rise to them converge to a point, and so present a star-like appearance. Others originate in the plexuses around the uriniferous tubules. The interlobular veins terminate by joining the convexities of the venous arches, which are situated between the cortex and the Malpighian pyramids.

Veins of the Medulla.—The veins of the Malpighian pyramids commence in plexuses which surround the excretory tubes or ducts of Bellini in the apical parts of the papillary zones, and they are called *venæ rectæ.* As these traverse the pyramids they are collected into bundles of straight vessels, which open into the concavities of the cortico-medullary venous arches.

Cortico-medullary Venous Arches.—These arches, which are complete, are situated between the cortex and the Malpighian pyramids, where they lie alongside of the incomplete arterial arches. They derive their blood from the interlobular veins of the cortex, and the venæ rectæ of the Malpighian pyramids. The veins which proceed from these arches pass between the pyramids to the sinus of the kidney, where they unite to form the renal vein, which terminates in the inferior vena cava.

Lymphatics.—These consist of two groups, superficial and deep. The **superficial lymphatics,** which are few in number, form a plexus in the fibrous capsule, and communicate with lymph spaces between the uriniferous tubules in the outer part of the cortex. They terminate by joining the deep lymphatics at the hilum. The **deep lymphatics** accompany the bloodvessels, and communicate with lymph spaces between the uriniferous tubules of the cortex and boundary layer. On emerging at the hilum they receive the superficial lymphatics, and then pass to the *median group* of *lumbar glands.*

Nerves.—The kidney receives numerous nerves from the renal plexus, which derives its fibres from (1) the aortico-renal ganglion, in which the small splanchnic nerve terminates; (2) the cœliac plexus; and (3) the aortic plexus. If there is a least splanchnic nerve present it reinforces the renal plexus. The nerve-fibres are partly sympathetic, partly spinal through the small and least splanchnic nerves, and in part derived from the right pneumo-gastric through the cœliac plexus. They accompany the arterial branches, and ramify upon the walls of the vessels and uriniferous tubules.

Excretory Apparatus of the Kidney.—This consists of the calices or infundibula, pelvis, and ureter.

Ureter.—This is the excretory duct of the kidney, and it has the form of a cylindrical tube, like a goose-quill, its colour being a dull white. Its length varies from 12 to 16 inches, and its diameter is about $\frac{1}{5}$ inch. At its lower extremity it opens into the bladder, and at the hilum of the kidney it presents a dilatation called the **pelvis of the kidney,** which is funnel-shaped, being wide above and narrow below. The pelvis is flattened from before backwards, and lies partly in the sinus and partly outside the hilum, its direction being downwards and inwards. It breaks up into two or three primary divisions within the sinus, and these again form secondary divisions, the resulting tubes being called **calices** or **infundibula,** which vary in number from 7 to 13. The number of calices thus falls short of the number of Malpighian pyramids (8 to 18), the explanation being that one calix grasps two papillæ or even three. The calices embrace the papillæ of the Malpighian pyramids, which thus project into them, and they receive the urine as it oozes through the pores on the apices of the papillæ, these pores being the openings of the excretory tubes or ducts of Bellini. The interspaces between the calices in the sinus are occupied by the branches of the renal bloodvessels and by fat.

Structure of the Ureter.—The ureter is a thick-walled muscular tube, lined with mucous membrane, and it consists of three coats—external or fibrous, middle or muscular, and internal or mucous. The **fibrous coat** is composed of fibrous tissue, very compactly arranged, and it contains the bloodvessels and nerves, which here subdivide. The **muscular coat** is composed of plain muscular tissue, which is disposed in three layers—*outer longitudinal, middle circular,* and *internal longitudinal.* The outer longitudinal layer is best marked in the lower half of the ureter, where it forms a continuous investment. In the upper half of the tube its bundles are somewhat scattered. The **mucous coat** superiorly is continued over the papillæ of the Malpighian pyramids, and inferiorly becomes continuous with the mucous membrane of the bladder. It is covered by stratified transitional epithelium, the cells being arranged in four layers. In the most superficial layer (nearest the lumen of the tube) the cells are cubical, and present depressions on their deep surfaces, which receive the round ends of the pyriform cells of the layer beneath. In the second layer the cells are pyriform, the round superficial ends being capped by the cubical cells of the first layer, and the narrow deep ends projecting between the deeper cells. In the third and fourth layers the cells are round or oval. The mucous membrane is thrown into longitudinal folds, and the lumen of the tube, which is of small size, presents under the microscope a branched appearance in cross section.

Blood-supply—Arteries.—The ureter receives branches from the renal, spermatic (ovarian in the female), common iliac, and superior vesical, arteries.

The **veins** terminate in the vessels corresponding to these arteries.

Lymphatics.—These pass to the *median group* of *lumbar glands*, and to the *internal iliac glands*.

Nerves.—These accompany the arteries, and are derived from the renal, spermatic (ovarian in the female), and pelvic, plexuses. The fibres form plexuses in the fibrous and muscular coats, which contain small ganglia.

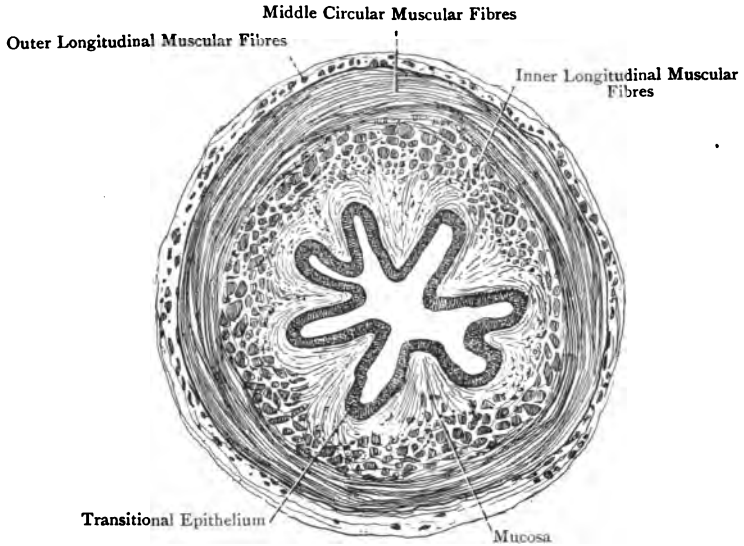


FIG. 348.—TRANSVERSE SECTION OF THE LOWER PART OF THE URETER, SHOWING ITS MINUTE STRUCTURE.

Structure of the Pelvis and Calices.—The structure of these parts of the excretory apparatus resembles that of the ureter, with the exception that they have only two layers of plain muscular tissue, instead of three as in the ureter. The layer which is wanting is the *outer longitudinal layer*. The calices are attached to the bases of the papillæ, and in these situations their fibrous coats become continuous with that part of the fibrous capsule of the kidney which is prolonged inwards through the hilum to line the sinus. The internal longitudinal muscular fibres disappear towards the papilla, but the circular muscular fibres accompany a calix to its termination, where they are arranged in the form of a circular band, which surrounds the base of a papilla at the line of attachment of a calix. The stratified transitional epithelium of the mucous coat of a calix is prolonged over the apex of each papilla.

Stroma of the Kidneys.—Between the uriniferous tubules and bloodvessels there is a certain amount of connective tissue, which is present in greatest abundance in the region of the papillary zones.

This constitutes what is known as the **fibrous** or **interstitial stroma,** of which there is a very small amount.

Early Condition of the Kidneys.—The kidneys of a child at the period of birth are lobulated, each lobule representing a Malpighian pyramid surrounded by cortical substance. In this respect they resemble the permanently lobulated kidneys of certain animals, *e.g.*, the ox. The lobules first become apparent towards the end of the third month of intra-uterine life, and all traces of them have usually disappeared by the eighth or tenth year. They may, however, remain persistent to a greater or less extent throughout life, though this condition is of very rare occurrence. It is, however, not uncommon to find the surface of an adult kidney marked by faint grooves indicative of its original lobulated condition. The disappearance of the lobulated condition is brought about by the adjacent lobules coalescing, this being accompanied by an increased development of cortical substance at the surface. The portions of cortical substance which remain in the spaces between the medullary pyramids (except their apical parts) represent the septula renum or columnæ Bertini.

Development of the Kidneys.—The kidneys belong to the uro-genital system, and are usually regarded as of mesoblastic origin. Each is developed in connection with a portion of mesoblast which is situated between the paraxial mesoblast and the pleuro-peritoneal cavity, and is known as the **intermediate cell-mass.**

First Stage.—In the very early embryo, from the second to the third week, a longitudinal cord makes its appearance, which is formed by a segmentation of mesoblastic cells from the intermediate cell-mass. This cord is at first solid, and is in close proximity to the epiblast, from which circumstance it is regarded by some authorities as being developed from the epiblast. It soon, however, acquires a lumen, and is then known as the **Wolffian duct.** Each Wolffian duct as it passes backwards lies within a fold of peritoneum, called the *uro-genital fold*, and the two ducts as they pass to the cloaca become embedded in a fold of connective tissue, called the *genital cord.* The posterior or caudal end of this duct opens into the posteror (lower) portion of the ventral or uro-genital compartment of the *cloaca*, which is the common opening of the uro-genital ducts and hind gut. The anterior or cephalic end of the Wolffian duct becomes attached to involutions of the peritoneal epithelium, between which tufts of capillary bloodvessels project into the peritoneal cavity. These capillary tufts form the **fore-kidney** or **pronephros,** which has only a temporary existence.

Second Stage.—This consists in the formation of the **mid-kidney, mesonephros,** or **Wolffian body.** This body takes the form of a number of tubes, called *segmental tubes*, which are developed in the mesoblast of the intermediate cell-mass, these tubes being transversely disposed at right angles to the Wolffian duct. They are at first solid, but each is subsequently provided with a lumen. By one extremity they open into the Wolffian duct, their other extremities being blind. These cæcal extremities, becoming enlarged, are invaginated, and each contains a tuft of capillary vessels. The Wolffian body attains its greatest development about the eighth week. As the permanent kidney becomes formed the Wolffian body begins to disappear, and it does so to a greater extent in the female than in the male. In the female vestiges of it are found in the parovarium or epoöphoron and the paroöphoron. In the male it gives rise to the tubuli recti of the testis, the tubes of the rete testis, the vasa efferentia, the coni vaculosi, the vas aberrans of Haller, and the paradidymis, or organ of Giraldés.

Third Stage.—This consists in the development of the **hind-kidney, metanephros,** or **permanent kidney.** The ureter and permanent kidney originate as a diverticulum from the posterior or caudal end of the Wolffian duct, close to where it opens into the ventral or uro-genital compartment of the cloaca at about the fourth week. This diverticulum is continued forwards to the mesoblastic tissue of the intermediate cell-mass. The part of it adjoining the Wolffian duct represents the *ureter.* The distal portion, becoming enlarged

forms the *pelvis*, and this, dividing into branches, gives rise to the *calices* or *infundibula*. The whole of the *uriniferous tubules* are now developed as tubular branches from the calices, which branches go on subdividing in the mesoblastic tissue of the intermediate cell-mass. Ultimately the distal cæcal extremity of each tubule, becoming dilated, is invaginated to form a *capsule of Bowman*, within which there is enclosed a tuft of capillary bloodvessels, representing a *glomerulus* or *Malpighian corpuscle*. Whilst this is one view of the development of the permanent kidney, according to which the whole of the uriniferous tubules spring from the branching calices, another view held by certain authorities must be stated. According to this view the following parts of the permanent kidney are developed from the ureteric diverticulum from the posterior part of the Wolffian duct, namely, the ureter, pelvis, calices, and collecting-tubes; whereas the convoluted tubules and Malpighian corpuscles are developed in the mesoblastic tissue of the intermediate cell-mass, and subsequently become connected with the branchings of the calices. At a later period the ureter becomes detached from the Wolffian duct, and opens into the anterior part of the ventral or uro-genital compartment of the cloaca. In the female the remains of the Wolffian duct are represented by the principal tube of the parovarium or epoöphoron, and the hydatids of Morgagni which are sometimes met with near the corpus fimbriatum of the Fallopian tube. In the male the Wolffian duct forms more important permanent structures, namely, the epididymis, the vas deferens, and the common ejaculatory duct, the vesicula seminalis being a diverticulum from the lower part of the latter.

The interstitial stroma of the kidney is developed from the mesoblastic connective tissue of the intermediate cell-mass.

THE PELVIS.

The pelvis is the lower division of the abdomen which lies below the level of the ilio-pectineal lines and sacral promontory. Unlike the abdomen proper the walls of the pelvis are chiefly osseous. The posterior wall is constructed by the sacrum and coccyx, with the origins of the pyriformes muscles. Each lateral wall is formed by the body and spine of the ischium, and is covered by the obturator internus muscle. The anterior wall is formed by the bodies of the pubic bones which, in the median line, construct the symphysis pubis. Between the posterior wall and each lateral wall is the large sacro-sciatic space, which is partly closed by the powerful great and small sacro-sciatic ligaments. This space is divided into two parts by the small sacro-sciatic ligament and the spine of the ischium. The upper part forms the great sacro-sciatic foramen, which transmits the pyriformis muscle, the gluteal vessels and nerves, the sciatic vessels and nerves, the internal pudic vessels and pudic nerve, the nerve to the obturator internus and gemellus superior, and the nerve to the quadratus femoris and gemellus inferior. The lower part forms the small sacro-sciatic foramen, which transmits the obturator internus muscle and its nerve, the internal pudic vessels, and the pudic nerve. At each lateral part of the anterior wall is the obturator foramen, which is closed, except superiorly, by the obturator membrane, covered by the obturator internus muscle. Below the symphysis pubis is the subpubic arch, which is occupied by the triangular ligament of the urethra. The

pelvic wall, thus constructed, is clothed by the pelvic fascia. Superiorly the pelvic cavity is quite open and in free communication with the abdomen proper. Inferiorly it is for the most part closed, a complex septum separating it from the perineum underneath. This septum is partly muscular and partly fascial. The muscles entering into it are the levatores ani and the coccygei, which construct the pelvic diaphragm. The fascial element is formed on either side by the visceral pelvic fascia, which clothes the superior or pelvic surface of the muscular diaphragm, and the anal fascia, which covers its inferior or perineal surface. The floor of the pelvis is consequently movable, being capable of ascending and descending. It affords passage to the rectum, and, in addition, to the vagina in the female.

Contents of the Pelvis.—The contents of the **male pelvis** are as follows: the pelvic colon and rectum; the bladder, with the lower portions of the ureters and the prostate gland, the latter containing the prostatic part of the urethra; the vesiculæ seminales and the lower portions of the vasa deferentia; the internal iliac vessels and their branches; portions of the superior hemorrhoidal and middle sacral vessels; the hemorrhoidal, vesical, and prostatic venous plexuses, the latter receiving the dorsal vein of the penis in two divisions; the sacral and sacro-coccygeal plexuses and their branches; the pelvic portions of the gangliated sympathetic chains; and the obturator nerves in part of their course.

The differences in the contents of the **female pelvis,** as compared with those of the male, are as follows:

For the prostate gland and prostatic portion of the urethra substitute the female urethra, uterus, and vagina. For the vesiculæ seminales and portions of the vasa deferentia substitute the broad ligaments of the uterus and their contents, namely, the Fallopian tubes, the ovaries with their ligaments, and the round ligaments of the uterus. Add to portions of the superior hemorrhoidal and middle sacral vessels portions of the ovarian vessels. For the prostatic venous plexus substitute the pudendal plexus, and add the uterine and ovarian venous plexuses.

The Male Pelvis.

General Position of the Viscera.—The pelvic colon and rectum are situated upon the posterior wall, the pelvic colon reaching as low as the third sacral vertebra, and the rectum extending thence downwards and forwards to the interval between the levatores ani muscles, where it is succeeded by the anal canal. The bladder is anterior in position, being situated behind the bodies of the pubic bones, and resting by its base upon the rectum. The vesiculæ seminales and the lower portions of the vasa deferentia lie in contact with the base of the bladder, between it and the rectum. The prostate gland surrounds the neck of the bladder and the prostatic part of the urethra.

Peritoneum.—The disposition of the peritoneum will be simplified

by defining the limits of the pelvic colon and rectum, and the different parts of the bladder. The **pelvic colon** extends from the inner border of the left psoas magnus, just anterior to the left sacro-iliac articulation, to the level of the third sacral vertebra. The **rectum** extends from the third sacral vertebra to a point 1½ inches in front of and below the tip of the coccyx, where it pierces the pelvic diaphragm to terminate in the anal canal, which is the part of the large gut surrounded by the sphincter muscles. The **bladder,** when empty, or only moderately distended, presents the following parts: (1) an apex, which is directed forwards, and lies behind the upper part of the symphysis pubis, where it has connected with it the fibrous cord representing the urachus; (2) a

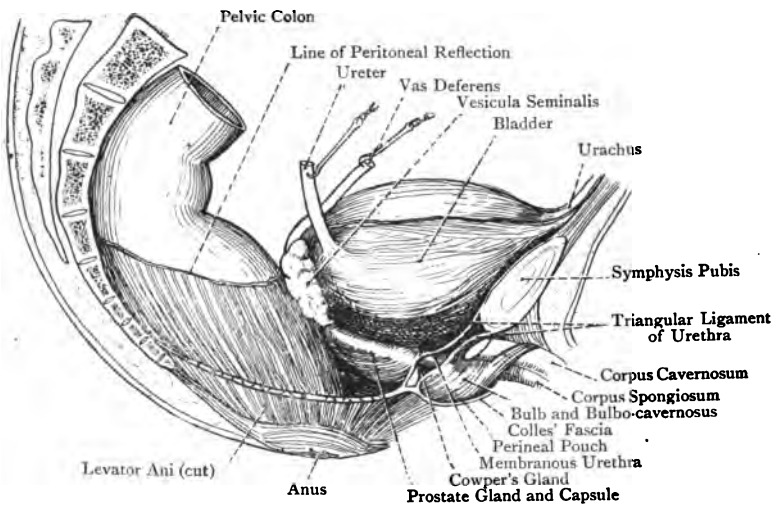


FIG. 349.—THE VISCERA OF THE MALE PELVIS (LATERAL VIEW).

base or fundus, directed backwards and downwards towards the rectum, from which it is separated by the vesiculæ seminales and vasa deferentia; (3) a body, which has a superior surface, an inferior surface, and three borders, two being lateral and one posterior; and (4) a neck.

The peritoneum, having descended from the posterior wall of the abdomen over the common iliac vessels, enters the back part of the pelvic cavity, where it invests the pelvic colon, forming behind it an expanded, wavy mesentery, called the *pelvic meso-colon*, which attaches it to the front of the sacrum as low as the third sacral vertebra. The peritoneum is then prolonged upon the rectum, the **upper third** of which it covers *anteriorly* and *laterally*, but not posteriorly, the **middle third** being covered by it only *anteriorly*, whilst the **lower third** is destitute of peritoneal covering.

The point at which the peritoneum leaves the rectum is fully 3 inches above the anus. The membrane is now carried forwards to the upper ends of the vesiculæ seminales, and the adjacent portions of the vasa deferentia, which it covers. Thereafter it passes forwards over the superior surface of the bladder, which it completely covers as far as the apex. Here it meets with the urachus, and by this it is conducted from the bladder to the posterior surface of the anterior abdominal wall. Along each lateral border of the bladder the peritoneum is reflected over the corresponding lateral wall of the pelvis. In passing from the rectum to the upper part of the base of the bladder, the peritoneum forms the **recto-vesical pouch.** The bottom of this pouch is, as a rule, fully 1 inch distant from the base of the prostate gland, thus leaving the part of the base of the bladder, called the external trigone, quite free from peritoneum. The peritoneum, as it passes to and from the bladder, forms certain folds, which constitute the **false ligaments** of the viscus. These are five in number, as follows: *two posterior*, which represent the laterally-disposed lips of the mouth of the recto-vesical pouch; *two lateral*, right and left, which represent the reflection of peritoneum from each lateral border of the bladder to the corresponding lateral wall of the pelvis; and *superior*, which is the reflection of the peritoneum from the apex of the bladder to the posterior surface of the anterior abdominal wall along the urachus. The parts of the bladder which are left uncovered by peritoneum are (1) the inferior surface, and (2) the external trigone.

The pelvic peritoneum on either side of the bladder and rectum presents three fossæ when these viscera are empty, which are named, from before backwards, *paravesical*, *paravesicular*, and *pararectal*.

Retro-pubic Pad of Fat.—This is a collection of areolar and adipose tissues which lies between the posterior aspect of the bodies of the pubic bones, the bladder, and the pubo-prostatic ligaments.

Pelvic Fascia.—This fascia clothes the inner wall of the pelvis, and furnishes inward expansions, which have an intricate connection with, and serve to support, the contained viscera. It is divisible into two portions—parietal and visceral.

Parietal Portion.—Over the posterior wall of the pelvic cavity the parietal portion of the pelvic fascia, which is here very thin, covers the intrapelvic portion of each pyriformis muscle and the corresponding sacral plexus, this portion being known as the *fascia of the pyriformis*. Over the lateral wall the fascia attains considerable strength, and is attached superiorly to the back part of the iliac portion of the ilio-pectineal line for a short distance, where it becomes continuous with the iliac fascia. In front of this the fascia falls short of the ilio-pectineal line, and is fixed to the lateral wall of the pelvis a little below the line, its attachment being oblique, and accurately following the upper border of the obturator internus muscle. When it arrives at the upper part of

the obturator foramen, there is a break in the osseous attachment of the fascia, which here joins the upper border of the obturator membrane over the upper border of the obturator internus, and so converts the obturator groove into a canal for the passage of the obturator vessels and nerve. At the upper and inner part of the obturator foramen the fascia resumes its osseous attachment, but falls more and more short of the pelvic margin, its connection with the back of the body of the os pubis being in a direction downwards and inwards till it reaches a point just below the lower part of the symphysis pubis. The fascia descends from the foregoing line of attachment, closely covering the obturator internus, to be

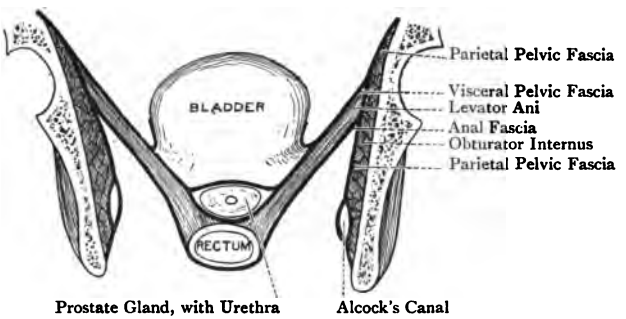


FIG. 350.—THE PELVIC FASCIA (ANTERIOR VIEW).

attached as follows from before backwards : (1) to the pelvic aspect of the ischio-pubic ramus near the subpubic arch, where it lies on the mesial side of the obturator internus ; (2) to the inner margin of the falciform process of the great sacro-sciatic ligament at the lower part of the ischial ramus, and also to the great sacro-sciatic ligament itself, where that is attached to the inner margin of the tuber ischii ; and (3) to a portion of the great sacro-sciatic ligament near its ischial attachment, and to the anterior margin of the great sciatic notch. The lateral portion of the parietal pelvic fascia, from its relation to the obturator internus muscle, is sometimes called the *obturator fascia*. From its lower attachment the fascia is continued backwards and inwards over the great sacro-sciatic foramen, pyriformis, and sacral plexus to the sacrum, as the fascia of the pyriformis. As it covers the foramen it is perforated by the gluteal, sciatic, and internal pudic vessels.

At the anterior part of the pelvic cavity the fascia, after taking attachment to the pelvic surface of the ischio-pubic ramus near the subpubic arch, is continued inwards over that arch, where it lies behind the compressor urethræ muscle, and forms one half of the postero-superior or deep layer of the triangular ligament, the other half being formed by the corresponding portion of the fascia of the opposite side. When it arrives at the urethra, it changes its course, and passes backwards over the anterior border of the

levator ani to blend with that portion of the visceral pelvic fascia which ensheathes the prostate gland.

In the direction of a line passing from the inner aspect of the ischial spine to the back of the body of the os pubis, near its lower end and close to the symphysis, the lateral pelvic fascia is strengthened by fibres which impart to it a white colour. This part is called the **white line,** and it serves to divide the fascia into two portions, upper or pelvic proper, and lower or perineal. The *pelvic portion* looks into the pelvic cavity, and covers the upper part of the obturator internus, whilst it is itself covered by the peritoneum. The *perineal portion* covers the lower part of the obturator internus, and lies on the outer wall of the ischio-rectal fossa, where it constructs Alcock's canal. The under aspect of the white line affords extensive origin to the levator ani muscle.

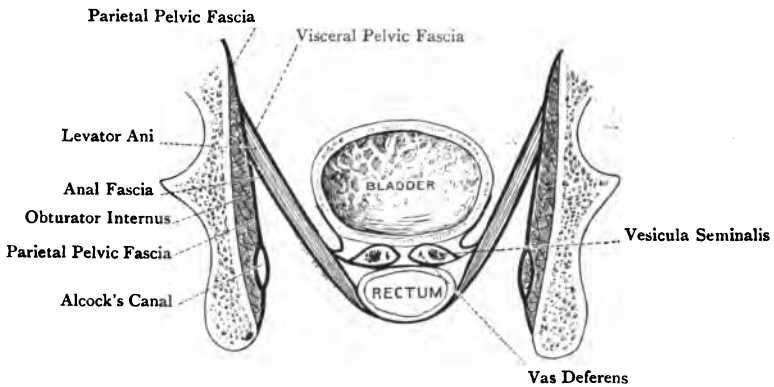


FIG. 351.—DIAGRAM OF THE PELVIC FASCIA FROM BEHIND.

Visceral Portion of the Pelvic Fascia.—The visceral portion is destined to support the lower part of the bladder, vesiculæ seminales, terminal portions of the vasa deferentia, prostate gland, and rectum. It is a laminar offshoot of the parietal portion, from which it springs along the white line. Though, however, this is its principal source, it has an independent origin anteriorly on either side of the middle line from the posterior aspect of the body of the os pubis near the lower part of the symphysis. In this latter situation it lies a little above the attachment of the parietal portion, the anterior fibres of the levator ani taking origin from the portion of bone between the two fasciæ. Though the visceral portion forms one continuous sheet along its pelvic attachment, its ultimate disposition is so intricate that it is convenient to consider its arrangement under three divisions.

1. *Opposite the bladder, vesicula seminalis, and rectum.* In this region the visceral portion of the fascia passes inwards as far as the outer border of the vesicula seminalis. In doing so it covers

the upper surfaces of the levator ani and coccygeus, and is in turn covered by the peritoneum. At the outer border of the vesicula seminalis it divides into three laminæ—upper, middle, and lower. The **upper** or **vesical lamina** ascends upon the lateral aspect of the bladder for a short distance, and ultimately loses itself in the muscular tissue of the vesical wall. This portion at each side forms the lateral true ligament of the bladder. The **middle** or **recto-vesical lamina** passes inwards between the base of the bladder and the rectum, and is continuous with the corresponding lamina of the opposite side. As it passes inwards it furnishes a sheath to the vesicula seminalis and adjacent portion of the vas deferens, closely strapping these structures to the base of the bladder. The **lower** or **rectal lamina** descends upon the side of the rectum, and passes to its posterior surface, where it is continuous with the rectal lamina of the opposite side.

2. *Opposite the neck of the bladder and prostate gland.* In this situation the visceral portion of the fascia also divides into three laminæ—upper, middle, and lower. The **upper** or **prostatic lamina** passes inwards over the anterior surface of the prostate gland, and is continuous with the prostatic lamina of the opposite side. The **middle** or **recto-prostatic lamina** passes inwards between the posterior surface of the prostate gland and the rectum, and is continuous with the corresponding lamina of the opposite side. The **lower** or **rectal lamina** is unaltered in its disposition. The upper or prostatic and middle or recto-prostatic laminæ furnish a stout sheath to the prostate gland.

3. *Between the pubic bodies and the upper aspect of the neck of the bladder.* The portion of the visceral fascia in this region represents the upper lamina in the other regions, and may be called the **pubo-prostatico-vesical lamina.** It is arranged in the form of two stout cords, which are known as the *pubo-prostatic ligaments* or the *anterior true ligaments* of the bladder. Each is attached anteriorly to the posterior aspect of the body of the os pubis, near the lower part of the symphysis, and a little above the attachment of the parietal portion of the pelvic fascia in this region, the anterior fibres of the levator ani taking origin from the portion of bone between the two fasciæ. As the cord-like fascial bands pass backwards they are connected by a portion of the visceral fascia which covers the dorsal vein of the penis and lies deeply, thus giving rise to a small pouch, which is capable of admitting the point of a finger. This pouch is filled with fat, which is continuous with the retro-pubic pad of fat. The anterior portion of the visceral fascia lies upon the anterior surface of the prostate gland, and on reaching the neck of the bladder it passes forwards to its inferior surface, where it soon disappears in the muscular tissue of the vesical wall. The pubo-prostatic ligaments are largely composed of plain muscular tissue, which is derived from the longitudinal fibres on the inferior surface of the bladder as they pass to take attachment to the back of the bodies of the pubic bones on either

side of the middle line. These fibres constitute the so-called *pubo-vesical muscles*.

Anal Fascia.—This very thin sheet of fascia is an offshoot from the parietal pelvic fascia just below the white line and the origin of the levator ani. It closely covers the ischio-rectal surface of that muscle and of the coccygeus, upon which it descends to the region of the anus, where it blends with the aponeurotic investment of the sphincter ani externus.

Sympathetic Plexuses in the Pelvis.—These are derived from the **hypogastric plexus**, which is formed by the fusion of the two lateral strands of the aortic plexus after they have crossed the common iliac arteries. It is reinforced by branches from the ganglia of the lumbar sympathetic cords, and is situated in front of the body of the fifth lumbar vertebra between the common iliac vessels. It is a large, flattened plexus, measuring about 1½ inches in breadth, and it breaks up into two divisions, which form the **right** and **left pelvic plexuses**. Each of these enters the pelvis on the inner side of the internal iliac artery, and takes up a position on the side of the rectum. The pelvic plexus of each side is reinforced by branches from the upper one or two ganglia of the pelvic sympathetic chain, and by spinal fibres from the anterior primary divisions of the third and fourth sacral nerves (sometimes also the second), there being very small ganglia at the places of junction. From each plexus the following secondary plexuses are given off, which accompany the corresponding branches of the internal iliac artery: hemorrhoidal, vesical, prostatic, vesicular, and deferential, the latter three being replaced in the female by the vaginal and uterine plexuses.

Internal Iliac Artery.—This vessel arises from the common iliac opposite the lumbo-sacral articulation, and terminates opposite the upper border of the great sciatic notch by dividing into an anterior and a posterior division. The length of the vessel is about 1½ inches, and its direction is downwards and backwards.

Relations—*Anterior.*—The artery is covered by the peritoneum, and the ureter descends over it. The terminal part of the ileum forms an anterior relation of the right vessel, whilst the pelvic colon is similarly related to the left. *Posterior.*—The vessel rests chiefly upon its own vein, but near its origin it is placed over the commencement of the common iliac vein. Behind the veins there are the lumbo-sacral cord and ala of the sacrum. *External.*—The psoas magnus, with the intervention of the external iliac vein, and subsequently the lateral wall of the pelvis, with the intervention of the obturator nerve. *Internal.*—The peritoneum.

Varieties.—The chief variety affects the length of the vessel. It may be shorter or longer than usual, according as the common iliac is longer or shorter than normal, or according to the height at which the internal iliac ends in its two divisions.

Fœtal Condition.—During fœtal life the internal iliac is represented by the **hypogastric** and **umbilical arteries**, the size of which greatly exceeds that of the external iliac. The function of these arteries is to carry the impure blood

from the fœtus to the placenta of the mother. The hypogastric artery passes forwards to the posterior surface of the anterior wall of the abdomen, being crossed by the vas deferens. It then ascends to the lower part of the umbilicus, where it leaves the abdomen with its fellow. Beyond the umbilicus the hypogastric is known as the umbilical artery, and the two umbilical arteries, together with the umbilical vein, form the umbilical cord, in which the arteries describe spiral coils around the vein. The arteries convey the impure blood to the placenta, where it is purified, after which it is returned to the abdomen of the fœtus by the umbilical vein. After birth, there being no further use for the placental circulation, the umbilical cord is tied, and the child separated from the mother. Thereafter the hypogastric arteries become impervious, and each is converted into a fibrous cord. The obliteration, however, does not involve the first 1½ inches of the vessel, which persist as the internal iliac artery of the adult. Moreover, the proximal end of the fibrous cord representing the obliterated hypogastric remains pervious also, and, being connected with the anterior division of the internal iliac, it furnishes the superior vesical artery or arteries. This pervious portion lies along the side of the pelvis beneath the peritoneum, where it is crossed by the vas deferens in the male, and the round ligament of the uterus in the female. The fœtal hypogastric artery gives off the sciatic, which is the primitive main artery of the lower limb, until the external iliac, which becomes the femoral, is developed.

Branches.—These are subject to much variation. In normal cases they arise from the two terminal divisions, anterior and posterior, some of them being parietal in their distribution, which will be indicated by the letter P, whilst others are visceral, which will be indicated by the letter V. The branches are as follows :

Anterior Division.		**Posterior Division.**
Visceral.	*Parietal.*	*Parietal.*
Superior vesical.	Obturator.	Ilio-lumbar.
Inferior vesical.	Internal pudic.	Lateral sacral.
Middle hemorrhoidal.	Sciatic.	Gluteal.

In the female the inferior vesical artery may be replaced by the vaginal, or the vaginal may be an independent branch, and the uterine artery is always a special branch.

Anterior Division.—The **superior vesical artery** (V) arises from the pervious portion of the fibrous cord which represents the fœtal hypogastric artery, and at once breaks up into several twigs which frequently have independent origins. They are distributed to the upper portion of the bladder, and anastomose with the vesical of the obturator, and the inferior vesical of the same side, and with the superior vesical of the opposite side. The superior vesical furnishes the following branches : *urachal* to the urachus ; *ureteric* to the lower end of the ureter ; and *deferential* (as a rule) to the vas deferens, though this branch may arise from the inferior vesical. The *deferential artery*, which is usually of small size, divides into a descending and an ascending branch. The descending branch passes downwards to supply the ampulla of the vas deferens, and the vesicula seminalis. The ascending branch accompanies the vas deferens through the internal abdominal ring and inguinal canal into the scrotum, supplying the vas deferens, and giving a few twigs

to the globus minor of the epididymis, in which latter situation it anastomoses with the epididymal branch of the spermatic artery. In the spermatic cord it also anastomoses with the cremasteric branch of the deep epigastric. The deferential artery is sometimes of large size, and then it takes the place of the spermatic artery, if that vessel should be absent. One of the branches of the superior vesical artery is sometimes spoken of as the middle vesical.

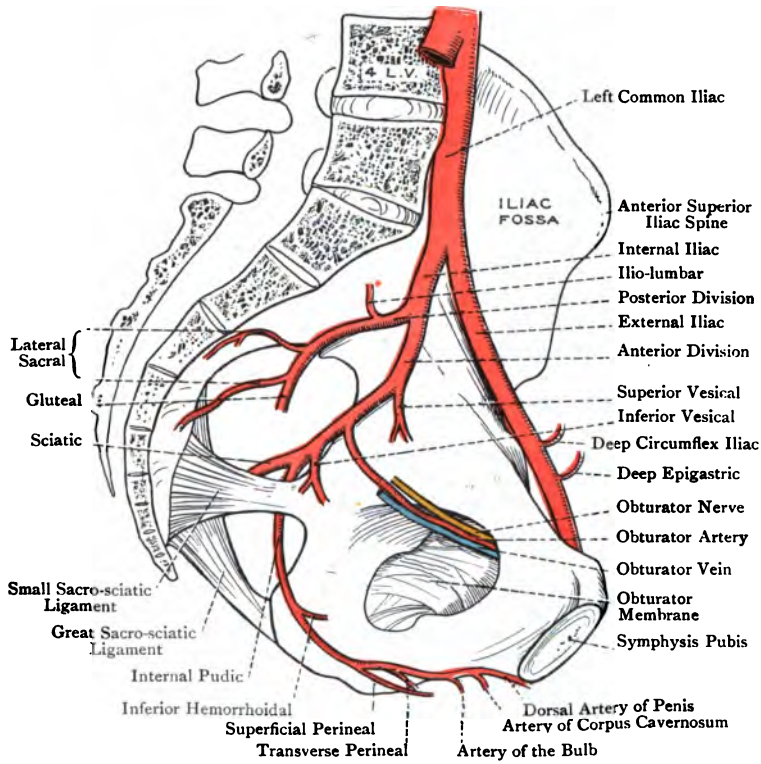


FIG. 352.—THE LEFT INTERNAL ILIAC ARTERY AND ITS BRANCHES.

The **inferior vesical artery** (V) takes an inward course to the lower portion of the bladder, which it supplies, giving branches to the vesicula seminalis, ampulla of the vas deferens, and prostate gland, and in the female to the vagina. It sometimes gives off the deferential artery, and it may give origin to an accessory pudic. It anastomoses with the superior vesical and middle hemorrhoidal of its own side, and with its fellow of the opposite side.

The **middle hemorrhoidal artery** (V) often arises in common with

...vesical. It is distributed to the rectum, and gives ...he vesicula seminalis, ampulla of the vas deferens, ...band. The anastomoses which it establishes are with ...emorrhoidal of the inferior mesenteric, the inferior ...the internal pudic, the inferior vesical of its own ...low of the opposite side.

...artery (P) passes along the outer wall of the pelvic ...way to the obturator canal, lying between the ...scia and the peritoneum. It has the obturator ...and its own vein below it. In entering the ...which it emerges from the pelvis, the artery ...the parietal pelvic fascia, but passes over its ...fibres that joins the upper part of the obturator ...the artery passes along the pelvic wall it furnishes ...branches: *muscular* to the obturator internus; ...ches, which supply the bone, psoas magnus, and ...anose with the iliac branch of the ilio-lumbar; ...the side of the bladder within the lateral ...to the back of the body of the os pubis, ...with the pubic branch of the deep epigastric ...and its fellow of the opposite side.

...of the obturator artery outside the pelvis,

...artery sometimes arises from the deep epigastric;

...pudic artery (P) is one of the terminal branches of ...It descends with the sciatic artery upon the ...muscles, and emerges from the pelvis through ...the great sacro-sciatic foramen, having ...pelvic fascia. The intrapelvic ...ant and are distributed to the ...muscles and pelvic fascia. For ...artery, see the gluteal ...58.

...terminal branch of ...the internal ...arises and emerges from ...the great sacro- ...the parietal pelvic ...branches to the ...bladder, vesicula

...the vessel, see

...artery passes upwards and ...between the lumbo- ...passes behind the ...vessels, and also ...reaching the back part

of the iliac fossa, it divides into two branches, iliac and lumbar, The *iliac branch*, passing transversely, ramifies in the iliacus and ilium, and anastomoses with the iliac branch of the obturator and branches of the deep circumflex iliac from the external iliac. The *lumbar branch* ascends beneath the psoas magnus on to the quadratus lumborum, where it anastomoses with the terminal part of the deep circumflex iliac, and the last lumbar of the abdominal aorta. In its course it furnishes a spinal branch, which enters the spinal canal through the intervertebral foramen between the fifth lumbar and first sacral vertebræ, to be distributed in a manner similar to the other spinal arteries.

The **lateral sacral arteries** (P) are usually two in number, superior and inferior. They course downwards and inwards to the front of the lateral mass of the sacrum, passing in front of the pyriformis and sacral nerves. Upon the sacrum both arteries lie external to the anterior sacral foramina, the superior being confined to the region of the first two foramina, whilst the inferior descends as low as the coccyx, where it anastomoses with the middle sacral artery. They are distributed to the pyriformis and sacral nerves, and furnish spinal branches, which enter the anterior sacral foramina, and so reach the sacral canal, where they supply its contents. Each spinal branch, before entering the sacral canal, gives off a posterior branch, which emerges through the posterior sacral foramen, and anastomoses with branches of the gluteal, sciatic, and internal pudic. The lateral sacral arteries anastomose with each other and with the middle sacral.

The **gluteal artery** (P) is a large vessel, which is the continuation of the posterior division. It is destined for the supply of the gluteal region, and lies within the pelvis for a very short distance. Its direction is backwards through the parietal pelvic fascia, and between the lumbo-sacral cord and the anterior primary division of the first sacral nerve, its escape from the pelvis being through the upper compartment of the great sacro-sciatic foramen. The branches of the artery within the pelvis are unimportant.

For the extrapelvic course and distribution of the vessel, see p. 405.

The branches of the internal iliac, with one exception, have to pierce the pelvic fascia. The exception is the **obturator artery,** which, as stated, passes over the upper border of the parietal pelvic fascia at the obturator foramen.

Internal Iliac Vein.—This vessel results from the union of branches which correspond, for the most part, with branches of the internal iliac artery. The ilio-lumbar vein, however, is an exception, inasmuch as it is a tributary of the common iliac vein. Moreover, during fœtal life the umbilical vein, which corresponds to the hypogastric (subsequently umbilical) artery, passes to the liver after entering the abdomen of the fœtus. The internal iliac vein extends from the upper part of the great sciatic notch to the sacro-

the inferior vesical. It is distributed to the rectum, and gives branches to the vesicula seminalis, ampulla of the vas deferens, and prostate gland. The anastomoses which it establishes are with the superior hemorrhoidal of the inferior mesenteric, the inferior hemorrhoidal of the internal pudic, the inferior vesical of its own side, and its fellow of the opposite side.

The **obturator artery** (P) passes along the outer wall of the pelvic cavity on its way to the obturator canal, lying between the parietal pelvic fascia and the peritoneum. It has the obturator nerve above it, and its own vein below it. In entering the obturator canal, by which it emerges from the pelvis, the artery does not pierce the parietal pelvic fascia, but passes over its upper border, where that joins the upper part of the obturator membrane. As the artery passes along the pelvic wall it furnishes the following branches: *muscular* to the obturator internus; *iliac* to the iliac fossa, which supply the bone, psoas magnus, and iliacus, and anastomose with the iliac branch of the ilio-lumbar; *vesical*, which reaches the side of the bladder within the lateral false ligament; and *pubic* to the back of the body of the os pubis, where it anastomoses with the pubic branch of the deep epigastric from the external iliac, and its fellow of the opposite side.

For the distribution of the obturator artery outside the pelvis, see p. 461.

The obturator artery sometimes arises from the deep epigastric; see p. 436.

The **internal pudic artery** (P) is one of the terminal branches of the anterior division. It descends with the sciatic artery upon the pyriformis and sacral nerves, and emerges from the pelvis through the lower compartment of the great sacro-sciatic foramen, having previously pierced the parietal pelvic fascia. The intrapelvic branches of the vessel are unimportant, and are distributed to the pyriformis, coccygeus, obturator internus, and pelvic fascia. For the further course and distribution of the artery, see the gluteal region and the perineum, pp. 408 and 586.

The **sciatic artery** (P) is the other and larger terminal branch of the anterior division. It descends, usually behind the internal pudic, upon the pyriformis and sacral nerves, and emerges from the pelvis through the lower compartment of the great sacro-sciatic foramen, having previously pierced the parietal pelvic fascia. Within the pelvis the artery gives off branches to the pyriformis, levator ani, coccygeus, rectum, bladder, vesicula seminalis, and prostate gland.

For the extrapelvic course and distribution of the vessel, see p. 407.

Posterior Division.—The **ilio-lumbar artery** (P) passes upwards and outwards in front of the sacro-iliac articulation, between the lumbo-sacral cord and obturator nerve. In its course it passes behind the external iliac, or, it may be, the common iliac, vessels, and also behind the psoas magnus and iliacus. On reaching the back part

of the iliac fossa, it divides into two branches, iliac and lumbar, The *iliac branch*, passing transversely, ramifies in the iliacus and ilium, and anastomoses with the iliac branch of the obturator and branches of the deep circumflex iliac from the external iliac. The *lumbar branch* ascends beneath the psoas magnus on to the quadratus lumborum, where it anastomoses with the terminal part of the deep circumflex iliac, and the last lumbar of the abdominal aorta. In its course it furnishes a spinal branch, which enters the spinal canal through the intervertebral foramen between the fifth lumbar and first sacral vertebræ, to be distributed in a manner similar to the other spinal arteries.

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iliac articulation on a level with the pelvic brim, where it joins the external iliac, and so the common iliac vein is formed. In its course it lies behind the corresponding artery. There are no valves in the vein itself, but its branches are freely provided with them.

The internal iliac vein is developed from the lower part of the cardinal vein.

Internal Iliac Lymphatic Glands.—These lie along the course of the artery, and are about ten in number. They receive their afferent vessels from the following sources: the deep lymphatics of the gluteal region, the upper part of the back of the thigh, and the upper part of the inner side of the thigh, the deep lymphatics of the penis (or clitoris in the female), bladder, vesicula seminalis, vas deferens, prostate gland, prostatic portion of the urethra and adjacent part of the membranous portion, lower two-thirds of the uterus, and upper two-thirds of the vagina. The internal iliac glands also receive the deep lymphatics of the perineum and the lymphatics of the back part of the scrotum. Their efferent vessels pass to the *median lumbar glands* through the intervention of the so-called common iliac glands.

Anterior Primary Divisions of the Sacral and Coccygeal Nerves.—There are five sacral nerves and one coccygeal nerve on either side. The anterior primary divisions of the first four sacral nerves emerge into the pelvis through the anterior sacral foramina, and that of the fifth sacral passes between the inferior lateral angle of the sacrum and the transverse process of the first coccygeal vertebra, through the coccygeus muscle. The anterior primary division of the coccygeal nerve enters the pelvis below the transverse process of the first coccygeal vertebra, through the coccygeus muscle. The first and second sacral nerves are of large size, and their course is obliquely downwards and outwards. Beyond the second they diminish rapidly in size, and pass more horizontally. They receive grey rami communicantes from the adjacent ganglia of the pelvic sympathetic cord, and the third and fourth nerves (sometimes also the second) furnish white rami communicantes to the corresponding pelvic plexus. The anterior primary divisions of the first and second sacral nerves divide each into an anterior or ventral and a posterior or dorsal branch. The anterior primary division of the third sacral nerve divides into an upper and a lower branch, and is known as the *nervus bigeminus*. The anterior primary division of the fourth sacral nerve also divides into an upper and a lower branch, and it is known as a *nervus furcalis*. The lumbo-sacral cord in two divisions, ventral and dorsal, the anterior primary divisions of the first two sacral nerves, the upper and lower branches of the third sacral, and the small upper branch of the fourth sacral form the sacral plexus, whilst the large lower branch of the fourth sacral, the fifth sacral, and the coccygeal form the sacro-coccygeal plexus.

Sacral Plexus.—This plexus, formed as stated, is a large flattened

mass, lying upon the pyriformis muscle, and behind the parietal pelvic fascia, which separates it from the sciatic and pudic vessels. The mass ultimately forms two bands, upper and lower. The **upper** or **sciatic band,** which is the larger of the two, receives the lumbo-sacral cord, first sacral, larger portion of the second sacral, and upper branch of the third sacral nerves. It is flat and somewhat triangular, and is continued into the great sciatic nerve, which leaves the pelvis through the lower part of the great sacro-sciatic

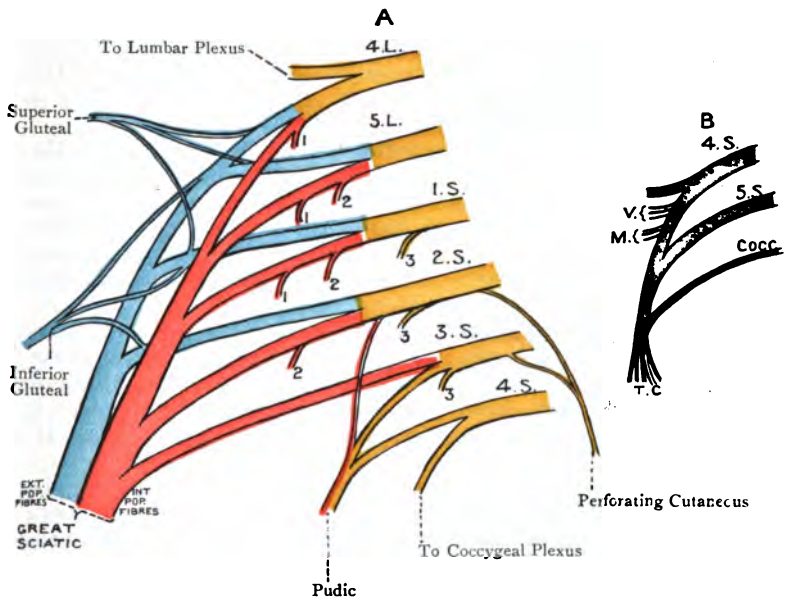


FIG. 353.—**A**, THE SACRAL PLEXUS; **B**, THE SACRO-COCCYGEAL PLEXUS.

A

1, 1, 1. Nerve to Quadratus Femoris
2, 2, 2. Nerve to Obturator Internus
3, 3, 3. Small Sciatic Nerve

B

4.S. Fourth Sacral, giving a Branch to Sacral Plexus
V. Visceral Branches
M. Muscular Branches
T.C. Terminal Cutaneous Branches

foramen below the pyriformis, without piercing the parietal pelvic fascia. The upper band and its contributory nerves are sometimes spoken of as the *sciatic plexus*. The **lower** or **pudic band,** the smaller of the two, receives fibres from the second, lower branch of the third, and upper branch of the fourth sacral nerves, and is continued into the pudic nerve, which leaves the pelvis, like the great sciatic, through the lower compartment of the great sacro-sciatic foramen without piercing the parietal pelvic fascia. The lower band and its contributory nerves are sometimes spoken of as the *pudic plexus*. The great sciatic and pudic nerves are

thus the terminal branches of the sacral plexus. The reason of the name *nervus bigeminus*, as applied to the third sacral nerve, is because it enters into the sciatic band by its upper branch, and into the pudic band by its lower branch.

Branches.—The branches of the sacral plexus are arranged in two groups—collateral and terminal.

Collateral Group.—The branches of this group form three sets —visceral, muscular, and cutaneous.

Visceral Branches.—These are derived from the third sacral and that part of the fourth which enters into the sacral plexus (sometimes also from the second). They are white rami communicantes, which reinforce the pelvic plexus of the sympathetic, a few of them being traceable independently to the pelvic viscera. They are known as the **pelvic splanchnics.**

Muscular Branches.—The **superior gluteal nerve** arises by three roots from the dorsal divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral nerves. It passes outwards and backwards, and leaves the pelvis with the gluteal artery through the upper compartment of the great sacro-sciatic foramen, to be distributed to the gluteus medius, gluteus minimus, and tensor fasciæ femoris muscles.

The **inferior gluteal nerve** arises by three roots from the dorsal divisions of the fifth lumbar and first and second sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, below the pyriformis and superficial to the great sciatic nerve, to be distributed to the gluteus maximus. It is usually intimately associated with the small sciatic nerve.

The **nerves to the pyriformis,** which are usually two in number, spring from the dorsal divisions of the first and second sacral nerves.

The **nerve to the obturator internus and gemellus superior** arises by three roots from the ventral divisions of the fifth lumbar and first and second sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, crosses the back of the ischial spine, where it lies external to the internal pudic vessels, and then passes through the small sacro-sciatic foramen to the outer wall of the ischio-rectal fossa, where it enters the inner or pelvic surface of the obturator internus. In the gluteal region it gives a branch to the gemellus superior when that muscle is present.

The **nerve to the quadratus femoris and gemellus inferior** arises by three roots from the ventral divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, and then lies between the ischium and the great sciatic nerve. It subsequently descends over the back of the capsular ligament of the hip-joint, to which it usually gives a branch, and beneath the gemelli and obturator internus to the deep surface of the quadratus femoris, in which it ends, having previously given a branch to the gemellus inferior.

Cutaneous Branches.—The **small sciatic nerve** arises by three roots from the posterior aspects of the first, second, and third sacral nerves. It leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, and is distributed to (1) the lower and outer part of the gluteal region by its gluteal cutaneous branches, (2) the integument of the scrotum by the long pudendal nerve of Soemmering, (3) the integument of the back of the thigh, and (4) the integument of the back of the leg as low as about the centre of the calf.

The **perforating cutaneous nerve** arises by two roots from the posterior aspects of the second and third sacral nerves. It passes backwards through the great sacro-sciatic ligament, after which it turns round the lower border of the gluteus maximus near the coccyx to be distributed to the integument over the lower and inner part of that muscle.

Terminal Group.—This group is comprised of two nerves, namely, the great sciatic and the pudic.

The **great sciatic nerve** is the continuation of the upper or sciatic band of the sacral plexus. In reality it is made up of the two divisions in which it ultimately ends, namely, the external and internal popliteal, which lie close together within the same sheath. Sometimes, however, these two divisions arise separately from the sacral plexus, in which cases the external popliteal nerve may pass through the pyriformis. Again, though the great sciatic nerve may be apparently single, a careful dissection of it, after the removal of its sheath, will reveal the external and internal popliteal nerves, which can be shown to have independent origins. The **external popliteal nerve** derives its fibres from the *dorsal* divisions of the descending branch of the fourth lumbar, fifth lumbar, and first and second sacral nerves; and the **internal popliteal nerve** derives its fibres from the *ventral* divisions of the foregoing nerves, and in addition from the upper branch of the third sacral.

The great sciatic nerve leaves the pelvis through the lower compartment of the great sacro-sciatic foramen below the pyriformis.

The **pudic nerve** is the continuation of the lower or pudic band of the sacral plexus. It arises by three roots from the ventral division of the second, the lower branch of the third, and the upper branch of the fourth sacral, the root from the third being the largest. The nerve leaves the pelvis through the lower compartment of the great sacro-sciatic foramen, crosses the back of the ischial spine, where it lies internal to the internal pudic vessels, passes through the small sacro-sciatic foramen, and then traverses the outer wall of the ischio-rectal fossa. Having given off the inferior hemorrhoidal nerve, it divides into the perineal and dorsalis penis nerves, which with the internal pudic vessels are contained in Alcock's canal.

The sacral plexus and its branches being situated behind the parietal pelvic fascia, the branches do not pierce that fascia as they leave the pelvis. The branches of the internal iliac artery, on the

other hand, being placed on the superficial surface of the parietal pelvic fascia, have to pierce it, with the single exception of the *obturator artery*.

Sacro-coccygeal Plexus.—The nerves which form this plexus are the lower branch of the anterior primary division of the fourth sacral, the anterior primary division of the fifth sacral, and the anterior primary division of the coccygeal nerve. The upper branch of the fourth sacral enters the pudic band of the sacral plexus, and the fourth sacral is therefore a *nervus furcalis*, inasmuch as it gives a branch to the sacral plexus and one to the sacro-coccygeal plexus. Before entering the sacro-coccygeal plexus the lower branch of the fourth sacral nerve gives off visceral and muscular branches. The *visceral branches* for the most part reinforce the pelvic plexus of the sympathetic as white rami communicantes, but a few of them pass independently to the pelvic viscera. The *muscular branches* supply the levator ani, coccygeus, and sphincter ani externus. The branch to the latter muscle reaches the perineum either by piercing the coccygeus, or by passing between it and the levator ani, and, besides supplying the external sphincter, it gives branches to the integument between the coccyx and the anus. The nerve is known as the *hemorrhoidal* or *perineal branch of the fourth sacral*. The lower branch of the fourth sacral nerve, having parted with the foregoing offsets, descends upon the coccygeus where it joins the fifth sacral, which has just entered the pelvis through that muscle. The conjoined nerve now descends, and is soon reinforced by the coccygeal nerve, which also enters the pelvis by piercing the coccygeus. In this manner the sacro-coccygeal plexus is formed. It lies at the lower part of the posterior wall of the pelvis upon the coccygeus, and the nervous loop takes a downward course. Subsequently it divides into several twigs, which leave the pelvis by piercing the coccygeus, the small sacro-sciatic ligament, and the adjacent portion of the gluteus maximus to be distributed to the integument over the coccyx.

Ureters.—The ureter of each side, having crossed the termination of the common iliac, or the commencement of the external iliac, artery, enters the pelvis. It then passes downwards and forwards in front of the internal iliac artery to the outer wall of the pelvis, lying beneath the peritoneum, and crossing internally the obturator vessels and nerve, and the obliterated hypogastric artery. It subsequently passes inwards to the bladder, being crossed internally by the vas deferens. Having arrived at the lateral or ureteric angle of the bladder, it passes obliquely through the vesical wall anterior to the upper free end of the vesicula seminalis, being here about 2 inches distant from its fellow, and about 1½ inches from the base of the prostate gland.

Bladder.—The bladder, when empty, or only moderately distended, lies entirely within the cavity of the pelvis. When, however, it is fully distended, the apical part of the viscus rises above the level of the symphysis pubis into the hypogastric region of

the abdomen for at least 2 inches, and, in cases of marked over-distension, it may reach to the umbilicus, or even higher. The bladder, therefore, has to be considered under two aspects, namely, when empty, or only moderately distended, and when fully distended.

The bladder, *when empty*, or *moderately distended*, is triangular, and presents the following component parts : an apex, a base, and a body, the latter presenting a superior surface, an inferior surface, two lateral borders, a posterior border, two lateral angles, and a neck.

The *apex* is directed forwards, and lies behind the upper part of the symphysis pubis. It has connected with it the fibrous cord representing the *urachus*, which ascends on the posterior surface of the anterior abdominal wall to the lower part of the umbilicus. The *base* or *fundus* is directed backwards and downwards towards the rectum, from which it is separated by the

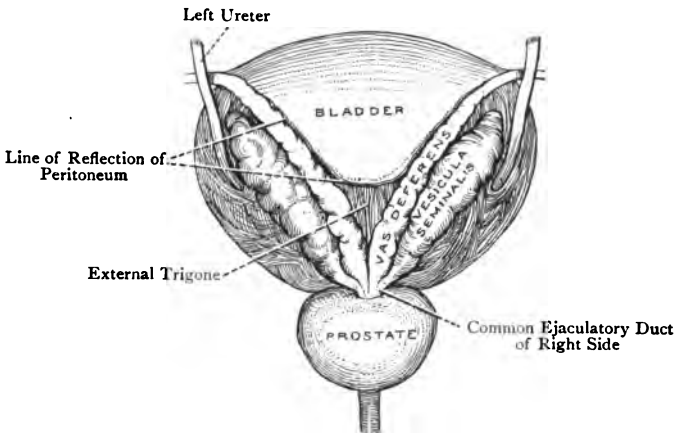


FIG. 354.—DISSECTION OF THE BASE OF THE BLADDER, SHOWING THE VESICULÆ SEMINALES, VASA DEFERENTIA, AND EXTERNAL TRIGONE.

vesiculæ seminales and terminal portions of the vasa deferentia, and the recto-vesical lamina of the visceral portion of the pelvic fascia. The base is separated from the superior surface by the posterior border, and from each rounded half of the inferior surface by a slight elevation, which extends from the lateral or ureteric angle of either side to the urethral opening. The *superior surface* is three-sided and slightly convex. It is usually related to a few coils of the small intestine, and a loop or two of the pelvic colon. The *inferior surface*, which is convex, rests upon (1) the symphysis pubis and the adjacent portions of the posterior surfaces of the bodies of the pubic bones, (2) the retro-pubic pad of fat, (3) the pubo-prostatic ligaments, and (4) the prostate gland. This surface, being rounded, is somewhat indefinitely divided into two lateral

portions. The *lateral borders* start from the apex, whence they pass backwards in a diverging manner, and each marks the separation between the superior surface and the corresponding half of the inferior surface. Posteriorly each lateral border meets the posterior border. The *posterior border* extends transversely between the superior surface and the base. At either end it is joined by the lateral border. The *lateral* or *ureteric angles* are situated on either side at the junction of the lateral with the posterior border. At these angles the ureters pass through the vesical wall. The *neck* is situated at the meeting of the base and inferior surface. It is surrounded by the base of the prostate gland, and it is in this situation where the vesical cavity becomes continuous with the urethra. The neck lies fully 2 inches behind the symphysis pubis, being a little lower than its upper border, and it is practically fixed in position by the prostate gland and pubo-prostatic ligaments.

The **external trigone** is the name given to a limited triangular space upon the exterior of the base, which is bounded as follows: above, by the bottom of the recto-vesical pouch of peritoneum; laterally, by the ampulla of the vas deferens, external to which is the vesicula seminalis; and below, by the approximation of the common ejaculatory ducts at the base of the prostate gland. The length of the space from the apex below to the base above is, as a rule, fully 1 inch, but its breadth is limited by the encroachment upon it of the deferential ampullæ. There is no peritoneum over this region.

The bladder during distension, and *when fully distended.* As the bladder becomes distended the neck alters its position only to a very slight extent in a downward direction. The demarcations between the component parts of the viscus gradually disappear, and it becomes ovoid. The apex appears above the symphysis pubis, and, as the organ increases in size, the apex and the superior portion of the body ascend into the hypogastrium in such a manner as to strip off the parietal peritoneum from the back of the linea alba. In this way a portion of the original inferior surface, *devoid of peritoneum*, is brought into direct contact with the back of the linea alba, which is now also *free from peritoneal covering*. A distended bladder may, therefore, be punctured or opened through the linea alba above the symphysis pubis without doing any injury to the peritoneum. The bladder is now becoming spheroidal, and its long axis is directed downwards and backwards. The part which rises highest is not the original urachal apex, but that part of the superior surface which is immediately adjacent to, and behind, the apex.

Peritoneal Relations.—The only part of the bladder which is covered by peritoneum is the superior surface. The peritoneum is reflected from the apex along the urachus, and at either side it leaves the organ along the lateral border. When the bladder is distended the lateral reflection of peritoneum appears to take place along the course of the obliterated hypogastric artery, but this

is due to the lateral distension and elevation of the viscus, the obliterated hypogastric itself lying along the outer wall of the pelvis. For the structure and development of the bladder, see pp. 810, 815.

Vas Deferens in the Pelvis.—The vas deferens enters the abdomen through the internal abdominal ring, where it lies on the inner side of the other constituents of the spermatic cord. It then hooks round the outer side of the deep epigastric artery, and, having crossed the external iliac vessels from without inwards, it dips down on the inner side of the external iliac vein. In this way it enters the pelvis under cover of the peritoneum. It now passes backwards and downwards upon the lateral wall, crossing the obliterated hypogastric artery and ureter, both on the inner side. Thereafter it is directed inwards to the inner aspect of the upper end of the vesicula seminalis, whence it passes downwards and inwards, and then vertically downwards upon the base of the bladder, where it lies close to the inner side of the seminal vesicle. This part of the vas deferens, which comes very near its fellow, is dilated and sacculated, like the adjacent vesicula seminalis, and is known as the **ampulla.** Close to the base of the prostate gland the sacculations disappear, and the duct, having become very narrow, is joined on the outer side at an acute angle by the duct of the seminal vesicle, and so the common ejaculatory duct is formed, which will be presently described. For the structure and development of the vas deferens, see pp. 630, 645.

Vesiculæ Seminales.—These are two in number, right and left, and lie between the base of the bladder and the rectum. They are sacculated reservoirs for the seminal fluid, and each is conical, being about 2 inches long, and about ½ inch broad at the widest part. The broad end is free, and looks upwards and outwards. It is covered posteriorly by the peritoneum which forms the recto-vesical pouch, and anterior to it is the ureter, as that is about to pass through the bladder. The upper ends of the two seminal vesicles are wide apart, and the bottom of the recto-vesical pouch descends between them for a short distance. The lower end of each, which is narrow and free from sacculations, approaches its fellow, the vasa deferentia intervening. This lower end represents the duct, which, as stated, joins the vas deferens at an acute angle close to the base of the prostate gland, and so gives rise to the common ejaculatory duct. For the structure and development of the vesiculæ seminales, see p. 816.

Common Ejaculatory Ducts.—These are two in number, right and left. Each is formed by the union of the duct of the vesicula seminalis with the vas deferens close to the base of the prostate gland, and it is about 1 inch in length. The two ducts pass downwards and inwards through the prostate gland, between the middle and lateral lobes, and each enters the lateral wall of the sinus pocularis. Thereafter each duct terminates in a minute aperture, which is situated either on the lateral margin of the opening of the

sinus pocularis, or immediately within the lateral margin. For the structure and development of the common ejaculatory ducts, see p. 817.

Prostate Gland.—This gland surrounds the neck of the bladder, as well as the first 1¼ inches of the urethra. It is firm in consistence, and in shape and colour resembles a chestnut—that is to say, it is conical and of a reddish-brown colour. It is subject to much variety in size, but its average measurements may be stated as follows: the transverse diameter at the base is about 1½ inches; the vertical diameter from base to apex is about 1¼ inches; and the antero-posterior diameter is about ¾ inch. The average weight of the organ is about 4½ drachms.

The gland is situated fully 1½ inches from the anus, and its anterior surface is about ½ inch behind the lower part of the symphysis pubis. It presents a base, an apex, a posterior or rectal surface, an anterior or pubic surface, and two lateral surfaces. The **base**, which is directed upwards, surrounds the neck of the bladder, and is intimately connected with the vesical wall. Notwithstanding this, however, there is a superficial line of demarcation between the two, which takes the form of an annular groove, occupied by a portion of the prostatic venous plexus. The common ejaculatory ducts enter the base close to the upper part of the posterior or rectal surface, where there is a small transverse cleft, called the *prostatic fissure*. The **apex** is directed downwards, and is the most dependent part of the organ. It is in contact with the postero-superior layer of the triangular ligament of the urethra. The **posterior** or **rectal surface** is flat and triangular. It is directed backwards and slightly downwards, and is set upon the anterior wall of the rectum, from which it is separated by the recto-prostatic lamina of the visceral portion of the pelvic fascia. This surface is accessible to manipulation on introducing the finger into the anal canal, and carrying it up for fully 1½ inches. The **anterior** or **pubic surface,** which is convex, is so much projected as to be really an anterior round border, which separates the two lateral surfaces. It lies about ½ inch behind the lower part of the symphysis pubis, from which it is separated by a portion of the prostatic venous plexus, the retro-pubic pad of fat, and the pubo-prostatic ligaments. The anterior surface projects between the anterior borders of the levatores ani muscles. The **lateral surfaces** are convex, and stand out in full relief. Each is embraced by the anterior fibres of the corresponding levator ani, which constitute the so-called levator prostatæ muscle. When an accessory pudic artery is present it passes over the lateral surface, and might be endangered in lateral lithotomy.

The gland is usually regarded as composed of three lobes, two lateral and a middle, but, though the middle lobe can usually be demarcated without much difficulty, there is no external indication of any separation between the lateral lobes. The **lateral lobes** form the chief bulk of the gland, and they meet and become con-

tinuous in front of and behind the prostatic portion of the urethra. The **middle lobe** represents that part of the basal portion of the gland which is wedged in between the common ejaculatory ducts and the adjacent portion of the neck of the bladder, and which lies just below the apex of the internal trigone. It is important to note that the middle lobe lies *behind* the commencement of the urethra. It is liable to become hypertrophied in old age, and then it may produce undue elevation of the uvula vesicæ in the interior of the bladder, which is a natural product of it. In this manner, by blocking the urethral orifice, it may not only give rise to difficulty in micturition, but may also obstruct catheterization.

The prostate gland is traversed by the first 1¼ inches of the urethra. The common ejaculatory ducts are also contained within the gland, in which they pass downwards and inwards between the middle and lateral lobes. For the structure and development of the prostate gland, see pp. 817 et seq.

Urethra.—The male urethra commences at the urethral orifice in the neck of the bladder, and terminates at the extremity of the

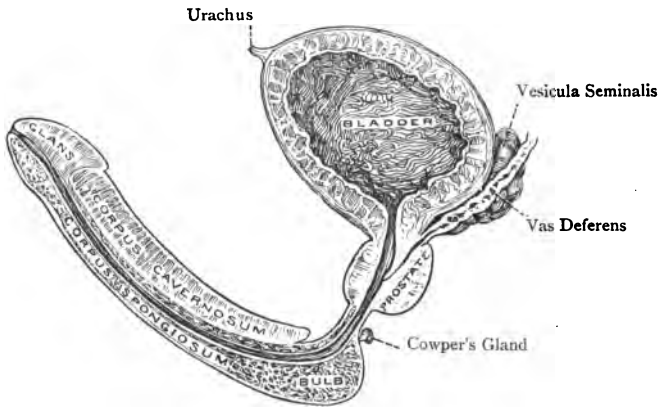


FIG. 355.—SECTION OF THE BLADDER AND PENIS TO SHOW THE URETHRA.

glans penis in a vertical fissure, called the **meatus urinarius.** It is about 8 inches in length, and is divided into three portions, which, from the bladder outwards, are called prostatic, membranous, and spongy. The prostatic and membranous portions constitute the *non-penile part* of the canal, and the spongy portion, being contained within the corpus spongiosum of the penis, represents the *penile part.*

The **prostatic portion of the urethra** is the part of the canal which is contained within the prostate gland. It is 1¼ inches in length, and its course is almost vertical, there being a slight curve with the concavity directed forwards. It is spindle-shaped, being wider at the centre than at either end, and at its upper or vesical

end it is rather wider than at the lower end. Its diameter at the centre, which is the widest part of the entire canal, is rather more than $\frac{1}{3}$ inch; at the upper or vesical end it is rather less than this; and at the lower end it is still less. This portion of the urethra, though surrounded by the prostate gland, is the most dilatable part of the whole canal. Close to the neck of the bladder, however, it usually offers some resistance to the passage of an instrument. Its walls are anterior and posterior, the latter being often spoken of as the *floor*. These walls are in contact with each other, except during the passage of fluid, and the mucous membrane is thrown into longitudinal folds. The **posterior wall** presents along the middle line a prominent narrow elevation of the mucous membrane, called the **crest.** The other names by which is is known are *verumontanum*, *caput gallinaginis*, and *colliculus seminalis*. It is about $\frac{3}{4}$ inch long, and commences either a little below the urethral orifice of the bladder or at the lower end of the uvula vesicæ. As it descends it gradually becomes more prominent, assuming a height of about $\frac{1}{8}$ inch, and then rapidly subsides. It is due to a thickening of the submucous tissue, which causes an elevation of the mucous membrane. On account of this projection a transverse section of this portion of the urethra is curved or crescentic, with the convexity directed forwards. On either side of the crest there is a longitudinal groove, called the **prostatic sinus,** into which the majority of the prostatic ducts open. A few of these ducts, however, from the middle lobe open in the median line above the crest, or, if the crest commences at the lower end of the uvula vesicæ, upon its upper part. Immediately below the most prominent part of the crest there is the opening of a small blind recess, called the **utricle.** The other names by which it is known are *sinus pocularis*, *vesicula prostatica*, and *uterus masculinus*. Its direction is upwards and backwards behind the middle lobe of the prostate, and it is from $\frac{1}{4}$ to $\frac{1}{2}$ inch in length. It is somewhat flask-shaped, being narrow at its urethral orifice, but expanded at its deep cæcal end. Upon the lateral margins of its orifice, or it may be just within them, there are the minute openings of the common ejaculatory ducts. The utricle represents the uterus and vagina in the female, being developed from the fusion of the posterior or caudal ends of the Müllerian ducts.

When the middle lobe of the prostate becomes hypertrophied, it blocks the urethral orifice of the bladder, as has been stated, by pressing the uvula vesicæ over it from behind, and so gives rise to difficulty in micturition, and obstructs catheterization. When both lateral lobes become uniformly hypertrophied, the prostatic portion of the urethra undergoes increase in length. When only one lateral lobe is involved in the hypertrophy it presses against the urethra, and, producing distortion of the canal, gives rise to difficulty in micturition, and often considerable obstruction in catheterization.

Structure.—The mucous membrane of the prostatic urethra is

surrounded externally by the inner circular muscular fibres of the prostate, and is covered internally by *transitional epithelium.*

The **membranous portion of the urethra** succeeds to the prostatic portion, and extends from the apex of the prostate gland to the commencement of the spongy portion. It is contained, for the most part, between the two layers of the triangular ligament, but it also extends for a short distance ($\frac{1}{4}$ inch) beyond the antero-inferior layer of that structure. It is the shortest and narrowest part of the canal, with the exception of the meatus urinarius. Its length is $\frac{3}{4}$ inch along the anterior wall, and $\frac{1}{2}$ inch along the posterior, the difference being due to the fact that the membranous urethra passes into the spongy part in a slanting manner at a point $\frac{1}{4}$ inch in front of the posterior extremity of the bulb. The back part of the bulb projects backwards for $\frac{1}{4}$ inch over the posterior wall of the membranous urethra, and is here lying in front of the antero-inferior layer of the triangular ligament. It is in this situation where a false passage is liable to be made in catheterization, partly because the walls are here very thin, and partly by reason of the backward extension of the posterior extremity of the bulb. The diameter of the membranous urethra is $\frac{1}{5}$ inch. It lies about 1 inch behind and below the subpubic ligament, and its direction is downwards and slightly forwards. It describes a gentle curve, the concavity of which looks forwards and upwards towards the lower part of the symphysis pubis. As the membranous urethra passes through the postero-superior layer of the triangular ligament, which is formed by the parietal pelvic fascia, the fascia is prolonged upwards to form part of the capsule of the prostate gland. Moreover, as it pierces the antero-inferior layer of the triangular ligament about 1 inch below the symphysis pubis, it carries with it a prolongation from the margins of the urethral opening, which forms a fascial investment for the bulb. Between the two layers of the triangular ligament the membranous urethra is surrounded by the fibres of the compressor urethræ muscle, and Cowper's glands lie behind it, one on either side of the middle line.

Structure.—External to the mucous membrane there is a layer of erectile tissue, and outside this there is a layer of circularly-disposed plain muscular fibres, which are continuous above with the circular muscular fibres of the prostate around the prostatic urethra. External to this, again, there are the sphincter fibres of the compressor urethræ. The mucous membrane is covered by *columnar epithelium.* The membranous portion of the urethra in transverse section presents the appearance of a circular opening, the lumen of which is branched, this being due to the longitudinal folds into which the mucous membrane is thrown.

The **spongy portion of the urethra** succeeds to the membranous portion. It is contained within the corpus spongiosum of the penis, and extends from a point $\frac{1}{4}$ inch in front of the posterior extremity of the bulb and of the antero-inferior layer of the triangular ligament to the meatus urinarius on the extremity of

the glans penis. It is about 6 inches in length, and its calibre is unequal throughout. It presents two dilatations, one situated in the **bulb** (which represents about the first 1½ inches of the corpus spongiosum), and the other in the glans penis, the latter being

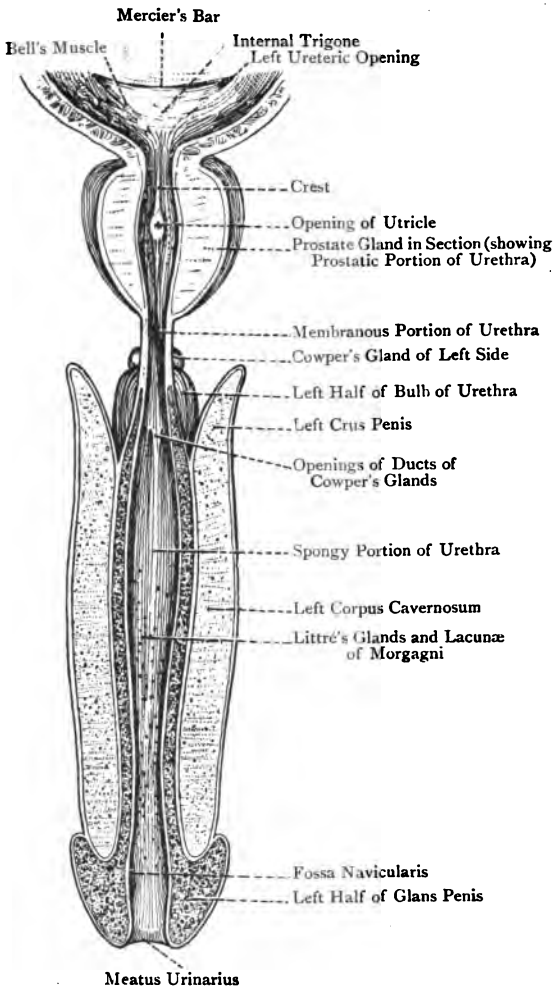


FIG. 356.—THE INTERIOR OF THE MALE URETHRA.

called the **fossa navicularis.** The bulbous enlargement is about 1¼ inches in length, whilst the fossa navicularis is about ½ inch long. The diameter of that part of the spongy urethra which intervenes between the bulbous enlargement and the fossa navi-

cularis is about ¼ inch. At the meatus urinarius the calibre of the canal is diminished, this being the narrowest part of the entire canal. The spongy portion at its commencement is directed forwards for a short distance, and then bends downwards. It thus describes a curve, which is situated about 2 inches from its commencement, the concavity being directed downwards. This curve is fixed, and corresponds with the **angle** of the penis, the situation of which is immediately in front of the penile attachment of the suspensory ligament, where drooping of the organ takes place. Another curve, but of a temporary nature, can be produced by raising the penis towards the abdomen, as in catheterization. The walls of the spongy part of the urethra are in contact, except during the passage of fluid. A transverse section of it, except in the glans, presents a transverse slit with anterior and posterior lips. In the glans, however, the slit is vertical with its lips laterally disposed. At the upper end of the fossa navicularis—that is, the end most remote from the meatus urinarius—the vertical slit is modified by the addition of a short transverse slit, and so presents the shape of an inverted T, as follows, ⊥.

Structure.—The mucous membrane of the spongy portion is provided with elastic tissue, and is very vascular. It is covered by *columnar epithelium*, except in the glans, where it is of the *stratified squamous* variety. Outside the mucous membrane is the submucous coat, which contains two layers of plain muscular tissue —inner longitudinal and outer circular. External to the submucous coat there is a plexus of veins, which forms part of the corpus spongiosum. The mucous membrane contains both simple and compound mucous glands, called the **glands of Littré**, the openings of the ducts of which are studded over the surface. In addition to these there are other openings, which lead into small blind recesses, called the **lacunæ of Morgagni,** these openings being directed forwards. One lacuna, of large size, called the *lacuna magna*, or *sinus of Guérin*, is situated on the roof of the fossa navicularis, about 1 inch from the meatus urinarius. The mucous membrane which surrounds this lacuna is known as the *valvule of Guérin*. Besides the foregoing openings, the ducts of Cowper's glands open upon the floor of the bulbous portion of the urethra about 1 inch in front of the antero-inferior layer of the triangular ligament.

There is sometimes a congenital deficiency in the floor of the spongy urethra, constituting the condition known as hypospadias. In other cases the deficiency may be on the roof, and it is then known as epispadias.

Lymphatics of the Urethra.—The lymphatics of the prostatic portion pass to the *internal iliac glands*, and those of the spongy portion pass to the *inguinal glands*. The lymphatics of the membranous portion pass partly with those of the prostatic portion to the internal iliac glands, and partly with those of the spongy portion to the inguinal glands.

Pelvic Colon.—The pelvic colon succeeds to the iliac colon. It commences at the inner border of the left psoas magnus, just anterior to the left sacro-iliac articulation, and terminates in front of the third sacral vertebra, where it becomes continuous with the rectum. It measures on an average about 15 inches in length, and usually lies in the pelvic cavity over the upper part of the posterior wall, where it rests below upon the bladder and rectum, and may descend on either side of these viscera. It is surrounded by peritoneum, which forms behind it an expanded wavy mesentery, called the **pelvic meso-colon,** which contains between its two layers the lower two sigmoid and superior hemorrhoidal arteries, with the corresponding veins. The root of this mesentery is composed of two limbs, which become continuous at an acute angle. One limb takes an upward course along the inner border of the psoas magnus, and the other passes downwards over the sacral promontory to be attached to the anterior surfaces of the first three sacral vertebræ. At its extremities, which are near each other, the mesentery is short, and the extremities of the pelvic colon are necessarily fixed. The intervening portion, however, is long, and so allows of considerable mobility on the part of the greater portion of the attached gut. A very common course for the pelvic colon to take is to pass to the right wall of the pelvis, where it bends and crosses to the left wall, and then bending again it passes to the right as far as the middle line. In such cases, therefore, it describes the letter **S**. A portion of it is sometimes met with in the abdominal cavity.

Structure.—The chief difference in the structure of the pelvic colon, as compared with the other divisions of the colon, affects the arrangement of the longitudinal muscular fibres. Though arranged at first in three tæniæ, these gradually become disposed as two broad tæniæ, anterior and posterior. When this has taken place, the longitudinal fibres almost surround the gut, except along the sides, in which situations the usual sacculations are formed. Appendices epiploicæ are met with over the pelvic colon.

Blood-supply.—The pelvic colon receives its **arteries** from the lower two sigmoid arteries, which are branches of the inferior mesenteric. The **veins** pass to the inferior mesenteric vein, and ultimately into the vena portæ.

The **lymphatics** pass to the *left lumbar lymphatic trunk.*

The **nerves** are derived from the inferior mesenteric sympathetic plexus.

Rectum.—The rectum succeeds to the pelvic colon, and extends from the front of the third sacral vertebra to a point 1½ inches in front of and below the tip of the coccyx, where it pierces the pelvic diaphragm, and terminates in the anal canal. Its direction is at first downwards and slightly backwards, then vertically downwards, and finally downwards and forwards. It is fully 5 inches in length, and its diameter, for the most part, is about

1½ inches in the empty state, but it becomes enlarged above the anal canal, this dilated part being called the **ampulla.** When empty, its anterior and posterior walls are in contact, and in transverse section it appears as a transverse slit. The rectum is destitute of a mesentery. The peritoneum covers the upper third *laterally* and *anteriorly*, but not posteriorly, the middle third being covered by peritoneum *only anteriorly*, whilst the lower third is free from serous covering. The point at which the peritoneum leaves the bowel is usually about 3 inches above the anus.

The rectum, so far from being straight in man, presents both antero-posterior and lateral curves. The **antero-posterior curves** are two in number, upper and lower. The *upper* curve extends from the third sacral vertebra to the posterior or rectal surface of the prostate gland, and its concavity is directed forwards. The *lower* curve, which is abrupt, corresponds with the rectal surface of the prostate, its concavity looking backwards, and containing the ano-coccygeal body. The **lateral curves** are of importance, because they tend to obstruct the passage of instruments by giving rise to the valves of Houston. These curves are usually three in number—upper, middle, and lower. The *upper* and *lower* curves have their convexities directed towards the right, whilst the *middle* curve has its convexity directed towards the left. In the concavities of these curves the rectal wall becomes inflected, and so gives rise to more or less prominent shelves of mucous membrane, which are known as the rectal valves of Houston. The lateral inflections and resultant valves are associated with the erect posture of man, which posture throws considerable pressure upon the anal aperture and its sphincter muscles. They are best marked in the distended rectum, and the lateral curves are brought about in the following manner: The longitudinal muscular fibres of the rectum are rather shorter than the gut to which they are applied. Moreover, they are principally disposed in two stout broad sheets, one on the anterior and the other on the posterior wall, there being very few longitudinal fibres along the lateral walls. The shortness of these longitudinal fibres, therefore, throws the rectum into lateral curves on account of the sparseness of the longitudinal fibres at the sides. These lateral curves may be taken as representing the sacculations of the other parts of the colon.

Relations—*Anterior.*—The recto-vesical pouch of peritoneum for a short distance; the base of the bladder, vesiculæ seminales, and vasa deferentia, with the intervention of the recto-vesical lamina of the visceral pelvic fascia; and the posterior or rectal surface of the prostate gland, with the intervention of the recto-prostatic lamina of the visceral pelvic fascia. In the female the anterior relations are (1) the recto-uterine pouch of peritoneum, or pouch of Douglas, with a few coils of small intestine, in front of which are the posterior surface of the body of the uterus and the upper part of the posterior wall of the vagina; and (2) the greater portion of the posterior wall of the vagina. *Posterior.*—The lower three

sacral vertebræ, coccyx, levatores ani, and ano-coccygeal body. Behind the rectum there is a large amount of areolar tissue. *Lateral.*—The pelvic sympathetic plexuses, levatores ani, and coccygei muscles, the lateral divisions of the superior hemorrhoidal artery, and the corresponding veins.

Anal Canal (Symington).—This is the terminal portion of the large intestine. It extends from the lower end of the rectum, where that has pierced the pelvic diaphragm at a point corresponding to the apex of the prostate gland, to the anus, and it is the part which is surrounded by the sphincter muscles. It is about 1½ inches in length, and its lateral walls are in contact, so that in transverse section it appears as an antero-posterior slit, in which respect it differs from the rectum proper. Its direction is downwards and backwards, and its antero-posterior measurement is from ½ to ¾ inch.

Relations—*Anterior.*—The bulb of the corpus spongiosum, the base of the triangular ligament, and the membranous part of the urethra. In the female the perineal body is anterior to it, and separates it from the lower end of the vagina. *Posterior.*—The ano-coccygeal body. *Lateral.*—The fat of the ischio-rectal fossæ. The anal canal is closely guarded by muscles in the following manner, and to the following extent: the sphincter ani externus surrounds its termination in the anal aperture, the levatores ani grasp it at its commencement, and the intervening part is surrounded by the sphincter ani internus. For the structure and development of the rectum and anal canal, see p. 818 *et seq.*

Parts felt per Rectum in Catheterization.—A catheter having been passed into the bladder, the following parts, in order from before backwards, may be felt through the anterior wall of the bowel on the introduction of the index finger: (1) the membranous portion of the urethra; (2) the posterior or rectal surface of the prostate gland; and (3) the apical part of the external trigone of the bladder, destitute of peritoneum, with a vas deferens on either side, and very near each other—indeed, almost touching. During this examination the finger may come in contact with the lower left, and perhaps the right, valve of Houston.

Middle Sacral Artery.—This vessel arises from the posterior aspect of the abdominal aorta just above the bifurcation. Its course is downwards in the middle line, behind the left common iliac vein and the hypogastric sympathetic plexus, and it rests in succession upon the following parts: the lower half of the body of the fourth lumbar vertebra and the disc between it and the fifth, the body of the fifth lumbar and the disc between it and the first sacral vertebra, and the pelvic surfaces of the sacrum and coccyx. In the pelvis it lies within the root of the pelvic meso-colon, being covered by a portion of the pelvic colon, as low as the third sacral vertebra, and beyond that it is placed behind the rectum. On reaching the tip of the coccyx it terminates in the coccygeal body. The branches of the artery are as follows: *anterior* or *rectal* to the posterior wall of the rectum, where they anastomose with the superior and

middle hemorrhoidal arteries; *lateral* to the front of the sacrum and coccyx, which anastomose with the lateral sacral arteries; and *terminal* to the coccygeal gland. The vessel occasionally furnishes a fifth pair of lumbar arteries, which wind round the sides of the body of the fifth lumbar vertebra.

The middle sacral artery represents the caudal aorta of animals, and its lateral branches are serially homologous with the lumbar branches of the abdominal aorta.

The **middle sacral vein** is at first arranged as two venæ comites, but these subsequently unite to form a single vessel, which usually terminates in the left common iliac vein.

Coccygeal Gland (Body) of Luschka.—This so-called gland is situated in front of the tip of the coccyx. It is about the size of a small pea, and is composed of a few nodules which are held together and invested by connective tissue. It receives the terminal twigs of the middle sacral artery. In structure it consists of groups of polyhedral cells, united by connective tissue, and permeated by blood-capillaries and sympathetic nerve-filaments. It is similar to the *carotid body*, which is situated behind the common carotid artery of each side close to its bifurcation.

Sacral Glands.—This group comprises a few lymphatic glands which lie in front of the sacrum along the middle line, behind the rectum. They receive their afferent vessels from the rectum and upper part of the anal canal, and from the posterior wall of the pelvis, and their efferent vessels pass to the *median lumbar glands*.

Gangliated Cord of the Sympathetic.—This is situated close to the inner side of the anterior sacral foramina. The two cords, right and left, converge as they descend, and in front of the coccyx they are connected by a loop which sometimes presents a single median ganglion, called the *ganglion impar* or *coccygeal ganglion*. The number of ganglia on each cord is usually four.

Branches.—(1) **Grey rami communicantes**, which spring from the ganglia and pass to the anterior primary divisions of the sacral and coccygeal nerves. These rami are very short. (2) **Visceral branches,** which pass from the upper one or two ganglia to the pelvic plexus. (3) **Parietal branches,** which are distributed over the front of the sacrum, and which communicate with those of the opposite side, so as to form a plexus upon the middle sacral artery. From the terminal loop and ganglion impar (when present) branches proceed to the front of the coccyx and coccygeal body. The ganglia of the sacral chain do not receive any white rami communicantes from the sacral nerves, these, under the name of the *pelvic splanchnics*, going chiefly to the pelvic plexus.

Levator Ani—*Origin.*—(1) The posterior surface of the body of the os pubis in its lower part, below the attachment of the pubo-prostatic or anterior true ligaments of the bladder, and above the attachment of the parietal pelvic fascia; (2) the internal surface of the parietal pelvic fascia along the **white line**; and (3) the pelvic

surface of the spine of the ischium in its lower part, below the coccygeus.

Insertion.—(1) The side of the lower part of the coccyx; (2) the post-anal or ano-coccygeal raphé, where it meets its fellow of the opposite side; (3) the wall of the anal canal, where the fibres blend with the longitudinal fibres of the gut, and ultimately pass with them between the external and internal sphincter muscles to be attached to the anal integument; and (4) the pre-anal raphé, and the central tendinous point of the perineum, where the muscle again meets its fellow of the opposite side.

The levator ani is a broad, flat, and thin fleshy muscle, the direction of which is downwards, inwards, and backwards, and with its fellow of the opposite side it forms an incomplete muscular floor to the pelvic cavity. It is covered on its pelvic aspect by the visceral portion of the pelvic fascia, and on its perineal aspect by the anal fascia, and in this manner a separation is formed between one half of the pelvic cavity and the ischio-rectal fossa of the same side.

The anterior border is free close to the body of the os pubis, but, after it passes downwards and backwards upon the side of the prostate gland in the male, or vagina in the female, it meets its fellow of the opposite side, between the prostate gland and the commencement of the membranous part of the urethra in the male on the one hand, and the rectum on the other, or between the vagina in the female and the rectum, the meeting taking place in the pre-anal raphé. Between the anterior borders of the two muscles the membranous part of the urethra in the male, and the vagina in the female, emerge from the pelvic cavity. The anterior or pubo-prostatic fibres are sometimes spoken of as the **levator** or **compressor prostatæ.** The posterior border adjoins the coccygeus muscle.

Nerve-supply.—(1) The anterior primary division of the fourth sacral nerve, and (2) the perineal branch of the pudic nerve (deep division).

Action.—(1) To elevate and support the floor of the pelvis, thus diminishing the vertical measurement of the abdominal cavity; (2) to compress the anal canal, and so assist in expelling its contents; (3) to elevate the anus; (4) to elevate and compress the prostate gland in the male, and the vagina in the female; and (5) to flex the coccyx.

Coccygeus (ischio-coccygeus)—*Origin.*—(1) The pelvic surface of the spine of the ischium, above the origin of the posterior fibres of the levator ani, and (2) slightly from the inner surface of the parietal pelvic fascia above the ischial spine.

Insertion.—The side of the upper two coccygeal and lower two sacral vertebræ.

Nerve-supply.—The anterior primary divisions of the fourth and fifth sacral nerves.

Action.—To flex the coccyx.

The coccygeus is a thin, flat, triangular muscle, the fleshy fibres having a large admixture of tendinous fibres. The internal or pelvic surface is related to the visceral pelvic fascia, sacro-coccygeal plexus and rectum, and the external surface to the small sacro-sciatic ligament. The superior border is adjacent to the pyriformis, with the intervention of the structures which leave the pelvis below that muscle. The inferior border adjoins the posterior border of the levator ani.

The coccygeus muscle is to be regarded as a detached portion of the levator ani.

The levatores ani and coccygei muscles form the *pelvic diaphragm*, which presents a superior concave, and an inferior convex, surface. The greater part of this diaphragm is formed by the levatores ani, and this part of it gives passage in the middle line to the rectum.

Pyriformis—*Origin.*—(1) By three fleshy slips from the anterior surfaces of the second, third, and fourth sacral vertebræ, which are interposed between, and lie external to, the adjacent anterior sacral foramina; (2) the deep surface of the great sacro-sciatic ligament; and (3) the posterior border of the ilium immediately below the posterior inferior spine.

Insertion.—The upper border of the great trochanter of the femur near its centre.

Nerve-supply.—Two branches from the sacral plexus, more particularly from the dorsal divisions of the first and second sacral nerves.

Action.—External rotator of the thigh.

The intrapelvic portion of the muscle is covered by a prolongation of the parietal pelvic fascia, called the fascia of the pyriformis, and it supports the nerves of the sacral plexus, branches of the anterior division of the internal iliac artery, and pelvic colon. For the extrapelvic portion, see p. 404.

Obturator Internus—*Origin.*—(1) The internal surface of the obturator membrane; (2) the posterior surface of the body and descending ramus of the os pubis, and ramus of the ischium; (3) the inclined plane of the ischium, extending as far back as the great sacro-sciatic foramen, and nearly as high as the iliac portion of the ilio-pectineal line; and (4) the parietal pelvic fascia covering the muscle.

Insertion.—The inner surface of the great trochanter above and in front of the digital fossa.

Nerve-supply.—The nerve to the obturator internus, from the sacral plexus.

Action.—External rotator of the thigh.

Relations of Intrapelvic Part—*Internal.*—As low as the *white line* the internal surface of the muscle is covered by the parietal pelvic fascia and peritoneum with the subperitoneal areolar tissue, and it is directed towards the pelvic cavity. The obturator vessels and nerve here lie between the subperitoneal areolar tissue and the parietal pelvic fascia. Below the level of the white line the internal

surface is still covered by the parietal pelvic fascia, which constructs Alcock's canal. This portion of the muscle lies upon the outer wall of the ischio-rectal fossa. *External.*—The internal surface of the obturator membrane, and the surrounding bone. For the extrapelvic part of the muscle, see p. 405.

STRUCTURE OF THE VISCERA OF THE MALE PELVIS.

The Bladder.

The wall of the bladder is composed of four coats—serous, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, and is very limited in its extent, being confined to the superior surface. It forms the false ligaments of the viscus.

The **muscular coat** consists of plain muscular tissue, which is arranged in three layers—external longitudinal, middle circular, and internal longitudinal.

The *external longitudinal fibres* are most apparent on the superior and inferior surfaces. Laterally they are scarce, and are disposed in an interlacing manner. They have an independent bony attachment to the posterior aspects of the bodies of the pubic bones near the lower part of the symphysis, where they constitute the so-called *pubo-vesical muscles.* They then pass within the pubo-prostatic ligaments to the neck of the bladder, where they are connected with the base of the prostate gland. Having covered the inferior surface as far forwards as the apex, some of them are there prolonged along the urachus for a short distance, whilst others turn to the superior surface over which they pass to the base. Having descended upon the base, they enter the prostate gland, where they blend with its muscular tissue. The longitudinal stratum has been called the **detrusor urinæ muscle** from its supposed function in expelling the urine from the bladder.

The *middle circular fibres* are somewhat indistinct, and more or less reticular over the greater part of the viscus. In the region where the fundus and inferior surface meet they become more distinct, and around the neck of the bladder, where the urethral opening is situated, they form a tolerably well-marked annular bundle, known as the **sphincter vesicæ,** beyond which they are continuous with the muscular tissue of the prostate gland.

The *internal longitudinal fibres* are somewhat indefinite, and are chiefly recognisable on the inferior surface.

When portions of the mucous membrane project between the scattered muscular bundles, the bladder is said to be *sacculated.* When, on the other hand, the muscular bundles become hypertrophied from any cause, such as enlarged prostate or stricture, they give rise to inward projections of the mucous coat, which are

arranged in a coarsely reticular manner, a condition known as the *fasciculated bladder.*

The **submucous coat** is situated between the muscular and mucous coats, which it connects in a loose manner for the most part, and it is composed of areolar tissue with an admixture of elastic tissue. It serves as a bed in which the arteries and nerves subdivide before entering the mucous coat.

The **mucous coat** is soft in consistence, and of a pinkish colour in health. It is continuous with the mucous membrane of the ureters and urethra, and over the greater part of the empty bladder is thrown into folds, which, however, disappear as the viscus becomes distended. This rugose condition is explained by the loose connection which exists between the mucous and muscular coats through means of the submucous coat. Over the internal trigone, however, to be presently described, the mucous membrane is quite smooth, and also very sensitive. The mucous coat is covered by stratified transitional epithelium, similar to that of the ureters. In the most superficial layer the cells are cubical, and they present depressions on their deep surfaces, which receive the round ends of the pyriform cells of the layer beneath. In the second layer the cells are pyriform, the round ends being capped by the cubical cells of the first layer, and the narrow ends being deeply placed amongst the deeper cells. In the third and fourth layers the cells are round or oval.

Orifices of the Bladder.—These are three in number, namely, urethral, and two ureteric. The **urethral orifice** is the opening by which the urine leaves the bladder, and it is situated at the posterior extremity of the inferior surface, where it meets the base. This is the most dependent part of the viscus, and corresponds with the neck, which is surrounded by the base of the prostate gland. Immediately above the urethral orifice the mucous membrane presents a short median vertical ridge, which projects forwards over the orifice. This ridge is called the *uvula vesicæ.* It is produced by the middle lobe of the prostate gland, and is much more conspicuous when that lobe is enlarged. The **ureteric openings** assume the form of small slit-like, somewhat elliptical, apertures, which are about 1¼ inches apart, and an equal distance from the urethral orifice, their direction being obliquely downwards and inwards. The ureters, before so terminating, have pierced the vesical wall obliquely, lying in it for about ¾ inch, and in this manner reflux of urine is prevented.

Internal Trigone of the Bladder.—This is situated at the lower part of the basal surface, and the mucous membrane over it is so closely connected to the muscular coat that it is always smooth, and so presents a marked contrast to the rugose condition of the mucous membrane over the rest of the empty bladder. The trigone assumes the form of an equilateral triangle, the angles of which correspond with the urethral and ureteric openings, whilst the sides are constructed by ridges connecting these openings. The inter-ureteric ridge, called *Mercier's bar,* is produced by a

bundle of muscular fibres, and is slightly convex, with the convexity directed downwards towards the urethral orifice. The urethro-ureteric ridge on either side is also produced by a bundle of muscular fibres, these bundles being known as the *muscles of Bell*. The uvula vesicæ is situated at the lower part of the trigone in the middle line, above the urethral orifice.

Lumen of the Empty Bladder.—This is very small, and is composed of two limbs, anterior and posterior. The *anterior limb*, which is long, lies almost horizontally in front of the urethral orifice, and is formed by the juxtaposition of the superior and inferior walls. The *posterior limb*, which is short, is directed upwards and backwards, and is formed by the juxtaposition of the back part of the superior wall and the base. The anterior and posterior limbs join each other at the urethral orifice, and are there continued onwards into the lumen of the prostatic urethra. A triradiate appearance is thus imparted to the lumen of the empty bladder and of the prostatic urethra, the three rays diverging from a central point, namely, the urethral orifice, one ray being urethral, and two vesical, of which latter one is the anterior limb of the vesical lumen, and the other the posterior limb.

The Infantile Bladder.—The bladder in early life is pyriform. The narrow end is directed downwards, and is on a level with the upper border of the symphysis pubis, from which point it gradually descends as age advances. The broad end is directed upwards, and lies in the hypogastric region of the abdomen. The base is absent at this period, and the anterior surface of the viscus, devoid of peritoneum, is in contact with the posterior surface of the anterior wall of the abdomen, which is likewise destitute of peritoneum. There being no base, the bottom of the recto-vesical pouch of peritoneum lies close to the base of the prostate gland.

Ligaments of the Bladder.—These are arranged as false and true ligaments. The **false ligaments** are formed by the peritoneum, and are five in number, as follows: *two posterior*, which represent the laterally-disposed lips of the mouth of the recto-vesical pouch; *two lateral*, right and left, which represent the reflection of the peritoneum from each lateral border of the bladder to the corresponding lateral wall of the pelvis; and *superior*, which is the reflection of the peritoneum from the apex of the bladder to the posterior surface of the anterior abdominal wall along the urachus. The **true ligaments** are also five in number, as follows: *two lateral*, right and left, which are formed by the vesical layers of the visceral portion of the pelvic fascia on the sides of the bladder; *two anterior* or *pubo-prostatic*, which are the reflections of the visceral pelvic fascia from the back of the bodies of the pubic bones near the lower part of the symphysis to the neck of the bladder, and which pass in their course over the anterior surface of the prostate gland; and *superior*, which is the urachus. Each anterior true ligament contains some of the external or longitudinal muscular fibres of the bladder.

Blood-supply—Arteries.—These are as follows: (1) superior vesical, from the pervious portion of the obliterated hypogastric; (2) inferior vesical, from the anterior division of the internal iliac; (3) vesical, from the intrapelvic portion of the obturator; (4) vesical, from the intrapelvic portion of the sciatic; and (5) branches from the uterine and vaginal arteries in the female.

Veins.—These are very copious, and are arranged in two plexuses—superior vesical and prostatico-vesical. The **vesical plexus** is situated over the fundus and sides of the bladder, and its blood is conveyed into the prostatico-vesical plexus. The **prostatico-vesical plexus** is composed of two parts, continuous with each other, namely, vesical and prostatic. The *vesical portion* surrounds the neck of the bladder, and its blood is conveyed by one or more vesical veins into the internal iliac vein.

Lymphatics.—These pass to the *external* and *internal iliac glands.*

Nerves.—Each half of the bladder receives sympathetic and spinal fibres from the following sources: (1) the pelvic plexus of the sympathetic, which contains spinal fibres from the third and fourth sacral nerves (sometimes also from the second), these being known as the *pelvic splanchnics;* and (2) special twigs from the pelvic splanchnics, which can be traced independently to the bladder. It is to be noted that the bladder also receives spinal fibres from the upper two or three lumbar nerves through the intervention of (*a*) the ganglia of the lumbar sympathetic cord, (*b*) the aortic plexus, (*c*) the hypogastric plexus, and (*d*) the pelvic plexus.

Structure of the Penis.

Corpora Cavernosa.—Each corpus cavernosum has a strong capsule, called the **tunica albuginea.** This tunic is composed of fibrous, plain muscular, and elastic tissues. It is disposed in two laminæ—external and internal. The fibres of the external lamina are arranged longitudinally, and are common to both corpora cavernosa. The fibres of the internal lamina run circularly round each corpus cavernosum, and in the middle line those of each side meet and are prolonged inwards as a septum, which is imperfect except near the root of the penis, being traversed by vertical clefts. This partition is called the **septum pectiniforme.** From the inner surface of the tunica albuginea strong trabeculæ are given off, which penetrate into the interior of the corpus cavernosum. These trabeculæ, which are fibro-muscular and elastic in character, are arranged in a reticular manner, and enclose the cavernous spaces of the erectile tissue. The artery of the corpus cavernosum lies in the centre, and, in addition to this chief vessel, several other arteries, derived from the dorsal artery of the penis, enter it from the surface. The branches of these arteries run in the trabeculæ, and terminate in capillaries, which pour their blood directly into the cavernous or intertrabecular spaces. Some of the small arteries in the trabeculæ are thrown into spiral loops, which project into the intertra-

becular spaces. Such vessels are called the *helicine* (spiral) *arteries* (Müller). From the intertrabecular spaces the radicle veins proceed, and by them the blood is returned from the organ.

Corpus Spongiosum.—This differs from the corpora cavernosa in being destitute of any bony attachments. Its length is about 6 inches, and it is expanded at either end. It is divided into a bulb, body, and glans. The glans has been already described (see p. 609). The **bulb** represents about the first 1½ inches of the corpus spongiosum, and at its widest part it measures ¾ inch. It

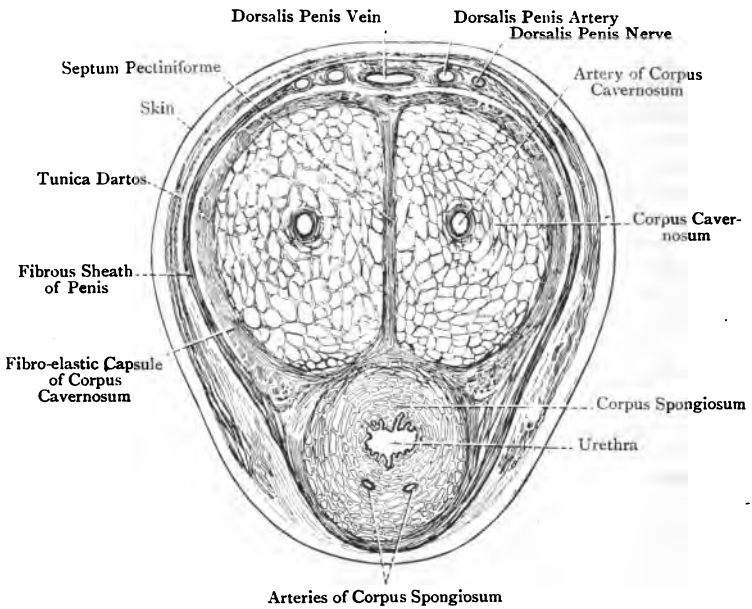


FIG. 357.—TRANSVERSE SECTION OF THE PENIS OF A CHILD AS SEEN UNDER A LOW POWER.

is surrounded by the bulbo-cavernosi muscles, and its enlarged posterior extremity rests upon the front of the antero-inferior layer of the triangular ligament of the urethra, where it is about 1 inch in front of the anus. The **body** is cylindrical. It has a capsule or tunica albuginea, but this is very thin. Within the capsule there is the erectile tissue, which resembles that of the corpora cavernosa, though not so well developed, and in the centre is the spongy portion of the urethra. The corpus spongiosum is traversed by the arteries of the corpus spongiosum, right and left, which are branches of the internal pudic arteries. They are situated underneath the urethral canal, one on either side of the middle line.

The venous blood of the corpora cavernosa and corpus spongiosum

is returned by the dorsal vein of the penis, and by the internal pudic venæ comites.

For the structure of the different parts of the urethra, see p. 800 *et seq.*

Development of the Bladder and Urethra—The Allantois.—The allantois is a hypoblastic diverticulum from the ventral wall of the hind-gut, which, with an investment of mesoblast, extends into the space between the true and false amnion. There are, therefore, two constituent parts in the allantois, namely, the hypoblastic diverticulum and its mesoblastic investment. This latter receives the embryonic allantoic or umbilical arteries, and, being very vascular, it carries bloodvessels to the villi of the chorion. The allantois thus establishes a communication between the hind-gut, which is intra-embryonic, and the chorion, which is extra-embryonic, and functionally it is associated with the nutritive and respiratory processes of embryonic life. The extra-embryonic and intra-embryonic parts are in continuity with each other through the umbilical opening. The former is of interest on account of its mesoblastic constituent, which, as has been stated, carries blood to the chorionic villi, and gives rise to the fœtal element of the placenta. The intra-embryonic part of the allantois is at first directly continuous with the upper part of the bladder, but in the course of the second month its lumen usually disappears, and then this portion is transformed into a fibrous cord, which is called the **urachus.** It is, however, to be noted that the lumen of the intra-embryonic part of the allantois may remain persistent for some time, thus giving rise to the condition which is known, after birth, as an umbilical urinary fistula.

The **bladder** is developed from the anterior or cephalic part of the ventral or uro-genital compartment of the cloaca, to which part the ureters are shifted when they cease to be connected with the Wolffian ducts. The *upper* portion of the **prostatic urethra,** as low as the sinus pocularis or uterus masculinus, is also developed from the anterior or cephalic part of the uro-genital compartment of the cloaca. and in the female the whole of the urethra is formed from it. The posterior or caudal part of this compartment, beyond the point of entrance of the Wolffian ducts, forms the uro-genital sinus. In the male it gives rise to the *lower* portion of the **prostatic,** and the *whole* of the **membranous, urethra,** whilst in the female it forms the portion of the uro-genital fissure close to the openings of the vagina and urethra.

It is to be noted that the upper portion of the prostatic urethra, as low as the sinus pocularis, represents the urethra of the female, whilst the uterus masculinus represents both the uterus and the vagina in the female, being developed from the fusion of the posterior or caudal ends of the Müllerian ducts. The cavity of the bladder is at first in direct continuity above with the lumen of the intra-embryonic part of the allantois.

Another view of the development of the bladder is that it is formed by a dilatation of the allantois at its proximal or cloacal end.

Development of the Spongy Portion of the Urethra.—The **cloaca,** which is the common opening of the hind-gut and uro-genital ducts, is bounded behind and below by a membrane, called the **cloacal membrane.** This membrane in very early embryonic life shuts off the cavity of the hind-gut from the exterior. It is composed of two layers, internal or hypoblastic belonging to the hind-gut, and external or epiblastic which is an invagination of the epiblast. The cloacal membrane forms the floor of a fossa, called the **cloacal fossa.** In the course of the second month the cloaca itself becomes partitioned off into two compartments by a septum formed of two lateral tranverse portions, which fuse in the middle line. The dorsal division is called the *rectal compartment,* and the ventral is termed the *uro-genital compartment.* Shortly afterwards a transverse fold appears, which crosses the cloacal fossa in such a position as to coincide with the posterior end of the internal partition. This transverse fold is called the **perineal fold.** In the female it gives rise to the perineum proper, and in the male it forms the tegmental parts of that

portion of the perineum which lies between the scrotum and the anus. The part of the cloacal fossa behind the perineal fold forms the **anal depression** or **proctodeum,** and the portion of the cloacal membrane which forms it is called the **anal membrane.** When the anal membrane disappears (about the third month) the anus becomes formed, and the rectal compartment of the cloaca now opens into the back part of the cloacal fossa. The uro-genital sinus, which is the posterior portion of the uro-genital compartment of the cloaca, opens into the cloacal fossa in front of the perineal fold by means of a narrow vertical cleft, called the **uro-genital cleft.** Shortly before the completion of the division of the cloaca into its two compartments (namely, about the fifth or sixth week), a prominence makes its appearance at the anterior or cephalic part of the cloacal membrane. This prominence receives the name of the **genital** or **sexual eminence,** and its importance consists in the fact that the penis and clitoris are developed from it. Leading backwards from the genital eminence there is a furrow, which ends at the uro-genital cleft. The genital eminence is surrounded at the front and sides by an epiblastic fold, called the **genital fold,** which, as it extends backwards, encloses between its two epiblastic layers the cloacal fossa and the cloacal membrane. The posterior surface of the genital eminence presents a groove, which is continuous with the uro-genital furrow. The lips of this groove, by their subsequent meeting and fusion, form a canal, which represents the part of the spongy urethra contained in the glans penis. Posterior to this the lips of the uro-genital furrow come together and unite as far back as the uro-genital cleft, and thus convert the front part of the cloacal fossa into a canal, which represents the spongy part of the urethra *behind the glans.* The spongy part is thus to be regarded as a forward extension of the uro-genital sinus, which opens at the uro-genital cleft. When the lips of the uro-genital furrow fail to meet and unite at any part, the condition known as hypospadias is produced, in which the spongy urethra opens externally on the under surface of the body of the penis. It is to be noted that, whilst the *prostatic* and *membranous portions* of the urethra are developed from the ventral or uro-genital compartment of the hypoblastic cloaca, the *spongy portion* is developed from the anterior part of the epiblastic cloacal fossa, the posterior part of that fossa giving rise to the anus and anal canal.

Structure of the Vesiculæ Seminales.

Each vesicula seminalis consists of a tube which is thrown into a number of coils, these being held together by fibrous tissue. When these coils are undone, and the tube straightened out, it measures from 5 to 6 inches in length. Its upper end is closed, and along its course several diverticula are met with. Each seminal vesicle in its natural sacculated condition is surrounded by a sheath, which is derived from the recto-vesical lamina of the visceral portion of the pelvic fascia. Within this sheath the tube has a fibrous wall composed of delicate fibrous tissue, and within this there is a muscular coat, which is formed of plain muscular tissue arranged in two layers—outer longitudinal and inner circular. Within the muscular coat is the mucous coat, which presents a number of reticular ridges with intervening alveoli. It thus bears a resemblance to honeycomb, in which respect it corresponds with the mucous membrane of the ampulla of the vas deferens and of the gall-bladder, the last-named having coarser meshes. The epithelium which covers the mucous membrane is of the columnar non-ciliated variety.

Blood-supply—Arteries.—These are derived from the inferior

vesical, the middle hemorrhoidal, the descending branch of the deferential artery, and the intrapelvic portion of the sciatic.

The **veins** are fairly large and numerous, and are disposed in a plexiform manner. They communicate with the prostatico-vesical plexus.

Lymphatics.—These go to the *internal iliac glands.*

Nerves.—These are derived from the pelvic plexus.

Development.—Each vesicula seminalis is developed as a diverticulum from the posterior or caudal part of the Wolffian duct, from which the vas deferens originates.

Structure of the Common Ejaculatory Ducts.

The wall of each duct is composed of three layers, as follows : an outer **fibrous layer,** which is very delicate ; a middle **muscular layer,** composed of an *outer circular* and *inner longitudinal* stratum ; and an inner **mucous layer,** lined by columnar non-ciliated epithelium.

Development.—Each duct is developed from the posterior or caudal part of the Wolffian duct.

Structure of the Prostate Gland.

The prostate gland is encased in a strong capsule, which is formed principally by the visceral portion of the pelvic fascia, and partly by the parietal pelvic fascia, in the following manner : the anterior wall of the capsule is formed by the prostatic lamina, and the posterior wall by the recto-prostatic lamina, of the visceral portion of the pelvic fascia ; and on either side the capsule is joined by the corresponding half of the deep or postero-superior layer of the triangular ligament of the urethra (which is formed by the parietal pelvic fascia), after it has passed backwards over the anterior border of the corresponding levator ani muscle. The capsule has a material influence in fixing the prostate gland in its position. Within this capsule there is the prostatic plexus of veins, and within this plexus there is another special capsule, composed of fibrous tissue, which immediately surrounds the glandular substance. The prostatic venous plexus is thus enclosed between the two capsules. The substance of the gland is composed of two elements—muscular and glandular. The **muscular tissue,** which is of the plain variety, is arranged as (1) an external, partly longitudinal and partly transverse, layer, which lies beneath the special fibrous capsule, and (2) an internal circular layer, which surrounds the prostatic urethra, being continuous above with the fibres of the sphincter vesicæ, and below with those around the membranous portion of the urethra. Between these two layers the muscular fibres pervade the gland in a decussating manner, so as to construct a muscular reticulum, the meshes of which contain the

glandular tissue. The chief part of the gland in front of the urethra is composed of muscular tissue. The **glandular element** consists of branched tubular alveoli or acini, the walls of which are formed by a basement membrane, covered internally by columnar epithelium. The tubular alveoli lead into the excretory or prostatic ducts, the structure of which is similar to that of the gland-tubes. The ducts average twenty in number, ten on either side, and they open by independent orifices upon the posterior wall of the prostatic portion of the urethra, for the most part into the prostatic sinus on either side of the crest.

Blood-supply—Arteries.—These are derived from the inferior vesical, the middle hemorrhoidal, and the intrapelvic portion of the sciatic.

The **veins** form a copious **prostatic plexus,** which is most plentiful over the anterior and lateral surfaces. It receives in front the dorsal vein of the penis in two divisions, and discharges its blood into the plexus which surrounds the neck of the bladder, and thence by one or more vesical veins into the internal iliac vein. The prostatic plexus is liable to become much enlarged in old age.

Lymphatics.—These pass to the *internal iliac glands.*

Nerves.—These are derived from the pelvic sympathetic plexus.

Development.—The glandular part of the prostate is developed from the epithelium of the uro-genital sinus. The epithelial cells in the course of the third month send out ramifying branches, which are at first solid, but subsequently become tubular, and so form the glandular part.

Structure of the Rectum.

The wall of the **rectum** is composed of five coats—serous, fascial, muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, and, as has been stated, is imperfect.

The **fascial coat** represents a sheath which is derived from the visceral pelvic fascia. In front of the rectum it is composed of the recto-vesical and recto-prostatic laminæ, whilst posteriorly it is formed by the rectal lamina of that fascia. It is best marked over the lower third of the rectum, where the peritoneum is absent. Elsewhere it is comparatively thin, and over the peritoneal area it merges into the subperitoneal areolar tissue.

The **muscular coat** is well developed, and is composed of plain muscular tissue, arranged as an external longitudinal and internal circular layer. The *longitudinal layer* is present all round the gut, but attains its greatest development along the anterior and posterior walls, where it forms two broad stout laminæ. Along the sides it is somewhat sparse. The *circular fibres* form a continuous covering for the rectum, and inferiorly they become increased in amount around the anal canal, and so give rise to the *sphincter ani internus.*

The **submucous coat** is composed of areolar tissue, and connects

the muscular and mucous coats in a very loose manner, so that the latter is thrown into a number of temporary folds in the empty condition of the gut. The internal hemorrhoidal plexus of veins is embedded in this coat.

The **mucous coat** is characterized by great thickness and vascularity. In health, therefore, it has a reddish colour, and is capable of free movement upon the muscular coat. The mucous membrane is covered by columnar epithelium, and is provided with crypts of Lieberkühn and lymphoid nodules. It is thrown into a number of folds in the empty state, but the majority of these are temporary, and become effaced when the gut is distended. There are, however, at least three permanent folds, which constitute the rectal valves of Houston. The mucous membrane is also studded over with a number of minute tubular depressions, called *rectal pits*, which are surrounded at their deep ends by lymphoid tissue (Birmingham).

The **rectal valves of Houston** are usually three in number, two being situated on the *left side* of the rectum, and one on the *right side*, and they are disposed horizontally. They take the form of crescentic folds, which are produced by inflections of the rectal wall in the concavities of the lateral curves, and they are best marked when the gut is distended. Each valve is composed of the mucosa, submucosa, circular, and deepest longitudinal muscular fibres. The **right valve,** which is intermediate in position, and usually the largest, is situated fully 3 inches above the anus. The **left valves** are situated one about 1 inch above, and the other about 1 inch below, that of the right side. These valves are sustentacular in function, serving to support the rectal contents, and it is possible that they may give rise to obstruction in the passage of instruments.

Structure of the Anal Canal.

The wall of the anal canal is composed of three coats—muscular, submucous, and mucous. The **muscular coat** is composed of plain muscular tissue, arranged as an external longitudinal and internal circular layer. The *longitudinal fibres* are continuous with those of the rectum, and, blending with them, there are fibres of the levator ani. Inferiorly they pass between the internal and external sphincters, to be attached to the anal integument. Associated with the plain longitudinal fibres on the posterior wall of the anal canal there are two minute muscles (sometimes united into one), called the *recto-coccygei muscles*. These spring from the front of the coccyx, and descend upon the posterior wall, where they blend with the longitudinal fibres.

There is nothing specially noteworthy in the submucous coat.

The **mucous coat** presents the columns of Morgagni, and the anal valves of Morgagni. The **columns of Morgagni** are six or more in number, and take the form of permanent vertical folds,

which are confined to the upper two-thirds of the anal canal, where they are separated from each other by longitudinal grooves. They are composed of inflections of the mucous membrane, which contain plain muscular tissue belonging to the muscularis mucosæ, and two small bloodvessels. They stop short about ½ inch above the anus. The **anal valves of Morgagni** are situated at the lower ends of the columns of Morgagni, about ½ inch above the anus. They lie in the lower ends of the longitudinal grooves, where they extend between adjacent columns, and they bear a resemblance to the valves which are met with in veins. They are semilunar folds of the mucous membrane, their free margins being directed upwards, and behind each valve there is a small recess or 'sinus.' The mucous membrane of the anal canal is replaced in the lower third (below the anal valves) by modified skin, continuous with that of the exterior. In the upper two-thirds of the canal the mucous membrane is lined by *columnar epithelium*, and in the upper third it is provided with a few Lieberkühn's crypts and lymphoid nodules. The cutaneous wall of the lower third of the anal canal is covered by *modified epidermic epithelium*, which is continuous at the anal margin with the epidermis. It is at the margins of the anal valves where this modified epidermic epithelium gives place to the columnar epithelium of the mucous membrane, and here also the modified skin of the lower third of the canal becomes continuous with the mucous membrane of the upper two-thirds. The point of transition is indicated by a faint line, which is known as the **white line of Hilton.**

Sphincter Ani Internus.—This so-called muscle is merely a thickening of the *circular* plain muscular fibres of the gut. It is confined to the region of the anal canal, and, viewing it as an independent muscle, or rather thickening of muscular tissue, it begins very near the upper end of the anal canal, and terminates about ½ inch above the anus. Though auxiliary to the external sphincter, the principal action of the internal sphincter is to expel the contents of the anal canal.

Blood-supply of the Rectum and Anal Canal—Arteries.—The rectum and anal canal receive their arterial supply from (1) the superior hemorrhoidal, which is a single vessel, (2) the middle hemorrhoidals, right and left; (3) the inferior hemorrhoidals, right and left; and (4) branches from the middle sacral and sciatic arteries.

The **superior hemorrhoidal artery** is of large size, and is the direct continuation of the inferior mesenteric. Having crossed the left common iliac vessels, it descends within the root of the pelvic meso-colon as low as the third sacral vertebra, where the rectum commences. Here it divides into two branches, right and left, which descend upon the sides of the rectum. From each of these divisions six or more branches are given off, which enter the rectal wall near its centre. Having pierced the muscular coat, they enter the submucous coat, and there subdivide into small terminal branches, which descend in the submucous coat as low as the anal valves, some of them lying within the columns of Morgagni. As these terminal branches descend they give off twigs, which, by anastomosing with branches of the middle and inferior hemorrhoidals, give rise to an arterial anastomotic network in the submucous coat. The disposition of the two primary divisions

of the superior hemorrhoidal artery on the sides of the rectum is to be borne in mind in the performance of Whitehead's operation for the removal of hemorrhoids.

The **middle hemorrhoidal arteries** are two in number, right and left, and are branches of the anterior divisions of the internal iliacs, often arising in common with the inferior vesicals. Having reached the sides of the rectum about its centre, they divide into branches, some of which supply the muscular wall, whilst others enter the submucous coat to take part, along with the superior and inferior hemorrhoidals, in the anastomotic network.

The **inferior hemorrhoidal arteries** are two in number, right and left, and each may be a single artery, or there may be two or three on each side. In any case, they are branches of the internal pudic, immediately after that vessel has taken up its position in Alcock's canal on the outer wall of the ischio-rectal fossa. Having pierced the wall of Alcock's canal, and traversed the fat of the ischio-rectal fossa, they approach the wall of the anal canal, where they break up into branches, some of which supply the muscular wall, including the external sphincter and adjacent fibres of the levator ani, whilst others pass into the submucous coat, where they take part, along with the superior and middle hemorrhoidals, in the anastomotic network already referred to. The middle and inferior hemorrhoidal arteries of one side anastomose with their fellows of the opposite side.

The rectum also receives twigs from the middle sacral and sciatic arteries.

Veins.—The veins, all of which are destitute of valves, form two rich plexuses, internal hemorrhoidal, situated in the submucous coat, and external hemorrhoidal, lying along the exterior of the rectum, both being confined to its lower third. The **internal hemorrhoidal plexus,** situated in the submucous coat, receives its radicles from a set of vessels, termed *anal veins,* which commence beneath the anal integument. These anal veins ascend in the wall of the anal canal, some of them lying within the columns of Morgagni, and they are reinforced by other veins from the anal wall. Having given rise by their communications to the internal hemorrhoidal plexus over the lower third of the rectum, the blood is conveyed away from the plexus in two channels as follows: (1) the veins from the upper part of the plexus pierce the wall of the rectum, and open into the external hemorrhoidal plexus; and (2) the veins from the lower part of the plexus pass through the external sphincter to end in a plexus on the outer surface of that muscle, in which the inferior hemorrhoidal veins originate. The **external hemorrhoidal plexus** is situated on the outer wall of the rectum over its lower third, and is continuous below with the plexus on the outer surface of the external sphincter. It is from this external hemorrhoidal plexus that the hemorrhoidal veins, which correspond with the hemorrhoidal arteries, pass off. The **superior hemorrhoidal vein** leaves the plexus in two divisions right and left, which ultimately join to form one vessel, the destination of which is the *inferior mesenteric vein.* It is, therefore, an indirect tributary of the vena portæ. The **middle hemorrhoidal veins,** right and left, terminate in the *internal iliac veins.* The **inferior hemorrhoidal veins,** right and left, pass to the *internal pudic veins.* Through means of the external hemorrhoidal plexus a free communication is established between the systemic and portal venous channels, and, there being no valves, when the portal circulation is obstructed the condition known as hemorrhoids frequently results.

Lymphatics.—The lymphatics of the rectum and *upper* part of the anal canal pass first to the *rectal glands,* which lie upon the wall of the rectum along the course of the superior hemorrhoidal vessels, and through them to the *sacral glands,* their further destination being the *median lumbar glands.* The lymphatics of the *lower* part of the anal canal are continuous with the cutaneous lymphatics around the anus, and pass to the *inguinal glands* which lie immediately below Poupart's ligament.

Nerves.—These are partly sympathetic and partly spinal. The superior hemorrhoidal artery conducts to the rectum and anal canal the superior hemorrhoidal sympathetic plexus, which is an offshoot from the inferior mesenteric plexus, that in turn coming from the aortic plexus. The middle hemorrhoidal arteries conduct the middle hemorrhoidal sympathetic plexuses, which are offshoots from the pelvic plexuses. The spinal fibres are derived from the third and fourth sacral nerves (sometimes also the second), and they belong to the pelvic splanchnics. They are further derived from the upper two or three lumbar nerves, all in the manner described in connection with the innervation of the bladder. The fibres from the *pelvic splanchnics* carry motor impulses to the longitudinal muscular fibres of the rectum, and inhibitory impulses to the circular fibres; whilst the *sympathetic fibres* are motor as regards the circular fibres, and inhibitory as regards the longitudinal fibres. The anal canal, close to the external sphincter, receives twigs from the inferior hemorrhoidal branch of the pudic nerve.

Development of the Rectum, Anal Canal, and Anus.—The rectum, and that part of the anal canal which lies *above* the anal valves, are developed from the hind-gut. The portion of the anal canal which lies *below* the anal valves, and the anus are developed from that part of the cloacal fossa which lies behind the perineal fold, and which is called the **proctodeum.** The septum between the hind-gut and the proctodeum is composed of the hypoblast of the hind-gut and the epiblast of the proctodeum, and, when this disappears about the third month of intra-uterine life, the intestinal tube and the proctodeum become continuous.

Congenital Deficiencies.—Congenital deficiencies in this part of the body are known as **imperforate anus** or **atresia ani.** The chief forms are as follows: (1) the anal membrane, which separates the proctodeum from the hind-gut, may be persistent. (2) The hind-gut may be deficient in its lower part. (3) The upper part of the anal canal may open into the bladder, vagina, or uterus. (4) The cloaca may remain permanent.

The Female Pelvis.

The female pelvis contains the pelvic colon and rectum, with a few coils of the small intestine; the bladder and urethra; the uterus and vagina; and the uterine appendages connected with the broad ligaments, namely, the Fallopian tubes, the ovaries, with the parovarium or epoöphoron, and paroöphoron (the latter in early life); and the round ligaments of the uterus. The arteries are the same as in the male, with the addition of portions of the ovarian arteries, and the uterine arteries, and the substitution of the vaginal arteries for the inferior vesical arteries in the male. The venous plexuses are hemorrhoidal, vesical, pudendal, ovarian, uterine, and vaginal. The nerve-plexuses peculiar to the female are the uterine, ovarian, and vaginal.

General Position of the Viscera.—The pelvic colon and rectum are situated as in the male pelvis. The bladder lies anteriorly, being situated immediately behind the bodies of the pubic bones,

and the urethra is very closely related to the anterior wall of the vagina. The virgin uterus lies upon the superior surface of the bladder, and the broad ligaments extend from either side of it to the lateral wall of the pelvis. The vagina passes off from the lower end of the uterus, and in its outward course it lies between the base of the bladder and the rectum.

Peritoneum.—The peritoneum is related to the pelvic colon and rectum as in the male. On leaving the rectum at a point fully 3 inches above the anus it passes to the posterior wall of the vagina, which it covers for about its upper fourth. It then mounts upwards over the posterior surface of the supravaginal portion of the cervix uteri and the body of the uterus. On reaching the fundus it turns round to the anterior surface, which it invests as low as the junction of the body and cervix. On leaving the viscus it passes to the upper part of the base of the bladder, whence it extends forwards over the superior surface, which it covers as far as the apex. Its course thereafter is as in the male. Along each lateral border of the bladder the peritoneum is reflected on to the lateral wall of the pelvis. Along either side of the uterus it is reflected on to the lateral wall of the pelvis, and in this manner the broad ligaments are formed. Between the rectum and the upper portion of the posterior wall of the vagina and supravaginal portion of the cervix uteri the peritoneum forms a recess, called the **pouch of Douglas,** which corresponds to the recto-vesical pouch in the male. The mouth of this pouch is bounded on either side by a semilunar peritoneal fold, which extends from the front of the sacrum over the side of the rectum to the cervix uteri. These folds are known as the **sacro-uterine folds,** or **recto-uterine folds of Douglas.** Each fold contains a collection of fibrous and plain muscular tissues, connected on the one hand with the fibrous structures in front of the lower part of the sacrum, and on the other with the cervix uteri. They become continuous with each other over the back of the isthmus uteri (junction of body and cervix), and there they give rise to a transverse ridge, called the **torus uterinus.** The pouch of Douglas is bounded in front by the upper part of the posterior wall of the vagina and the supravaginal portion of the cervix uteri, and behind by the rectum. In front of the uterus the peritoneum gives rise to a small recess, called the **utero-vesical pouch,** the entrance to which is bounded laterally by two folds, called the **utero-vesical folds.** As regards the bladder, the peritoneum forms for it false ligaments as in the male, namely, one superior, two lateral, and two posterior. The latter are simply the utero-vesical folds, and may be regarded not only as posterior ligaments of the bladder, but also as anterior ligaments of the uterus.

Pelvic Fascia.—The parietal pelvic fascia in the female is similar to the corresponding fascia in the male. The visceral pelvic fascia, however, is complicated by the interpolation of the vagina. On either side of the pelvic viscera it divides into four laminæ, as follows: *vesical,* which forms, on either side, the lateral true liga-

ment of the bladder; *vesico-vaginal*, which passes between the bladder and the vagina; *recto-vaginal*, which passes between the vagina and the rectum; and *rectal*, which passes over the sides and posterior wall of the rectum.

Broad Ligaments of the Uterus.—These are also called the *alæ vespertilionis*, from their supposed resemblance to a bat's wings. Each is an extensive fold of peritoneum composed of two layers,

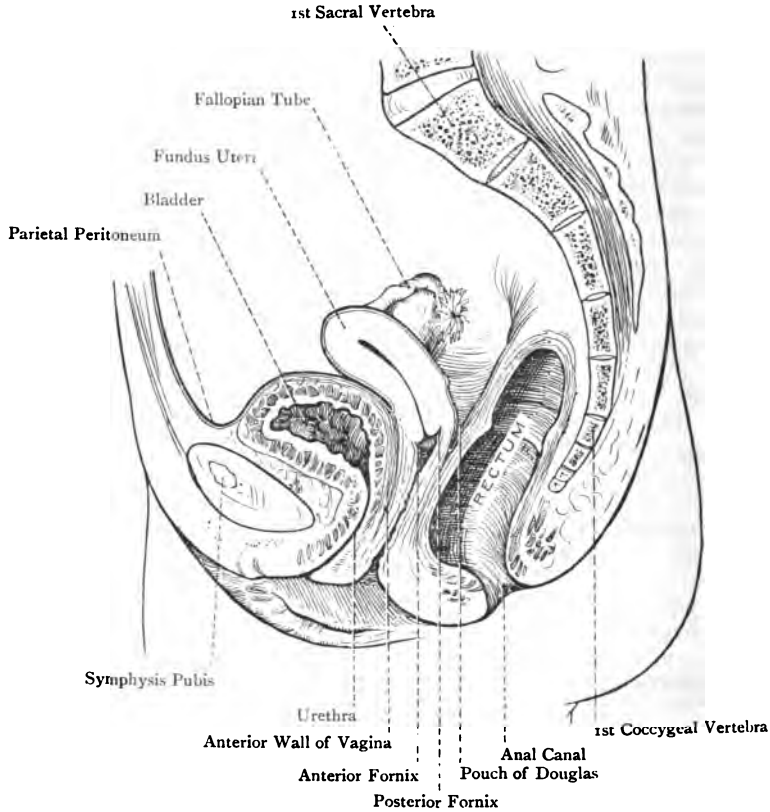


FIG. 358.—VERTICAL SAGITTAL SECTION OF THE FEMALE PELVIS.

anterior and posterior, which pass between the side of the uterus and the lateral wall of the pelvis. The broad ligament has associated with it the following important structures: (1) the Fallopian tube or oviduct, which lies within the superior border of the ligament; (2) the ovary and its ligament, which lie within a backward extension of the posterior layer of the broad ligament at a lower level than the Fallopian tube; (3) the round ligament of the uterus,

which lies within a forward projection of the anterior layer of the broad ligament, also at a lower level than the Fallopian tube; (4) the epoöphoron, which lies within the ligament between the ovary and the Fallopian tube; and (5) the paroöphoron (in early life), which also lies within the ligament, internal to the epoöphoron and near the uterus. The double fold of peritoneum attaching the anterior border of the ovary over its whole length to the back of the broad ligament forms a short mesentery for it, called the **mesovarium,** which contains between its two layers the blood-vessels and nerves of the ovary. The portion of the broad ligament which lies between the Fallopian tube and the ovary with its ligament is called the **mesosalpinx.** It is somewhat falciform, and is narrow internally, but broad externally. It is bounded above by the Fallopian tube, below by the ovary and its ligament, internally by the uterus, and externally by the ovarian fimbria and the suspensory ligament of the ovary.

Round Ligament of the Uterus.—This is a narrow, cord-like band, about 5 inches long, which is attached to the upper part of the side of the uterus in front of, and a little below, the uterine end of the Fallopian tube. It is composed of fibrous connective tissue, which, near the uterus, has an admixture of plain muscular fibres continuous with those of the uterus. It lies within the anterior layer of the broad ligament, where it gives rise to a slight prominence. Its direction is outwards, upwards, and forwards over the obliterated hypogastric artery and pelvic brim to the internal abdominal ring, close to which it hooks round the outer side of the deep epigastric artery, and crosses the external iliac vessels from within outwards. Escaping by the internal abdominal ring, it traverses the inguinal canal, and, emerging through the external abdominal ring, it ends in the subcutaneous tissue of the labium majus. For a short distance after entering the inguinal canal it is covered by a process of the peritoneum, which represents the processus vaginalis in the male fœtus. This process is at first tubular, and receives the name of the **canal of Nuck.** It is usually, however, obliterated in the adult, though it may remain pervious, under which circumstances the condition known as hydrocele of the round ligament may occur. A few muscular fibres may be found in front of the round ligament in the inguinal canal, which are continuous with the lower fibres of the internal oblique, and represent the cremaster in the male.

The round ligament is supplied by two arteries as follows: the ligamentous branch of the ovarian artery, which supplies it as far as the inguinal canal; and the ligamentous branch of the deep epigastric, which supplies it beyond the internal abdominal ring, and corresponds to the cremasteric artery in the male. The principal venous blood is returned by a ligamentous vein, which is a tributary of the ovarian plexus.

The round ligament represents the lower portion of the gubernaculum testis in the fœtal male.

Ovaries.—The ovaries are two small flattened bodies, each of

which lies within a backward extension of the posterior layer of the broad ligament, with which it is connected by the mesovarium. The ovary is laterally compressed, and usually lies, with its long axis vertical, against the lateral wall of the pelvis in a peritoneal depression, called the *ovarian fossa*. It may, however, lie obliquely, and may even be shifted near to the uterus. In size it may be likened to the half of a small walnut, its average length being from 1 inch to 1½ inches, its breadth about ¾ inch, and its thickness (from side to side) from ¼ to ½ inch. Its average

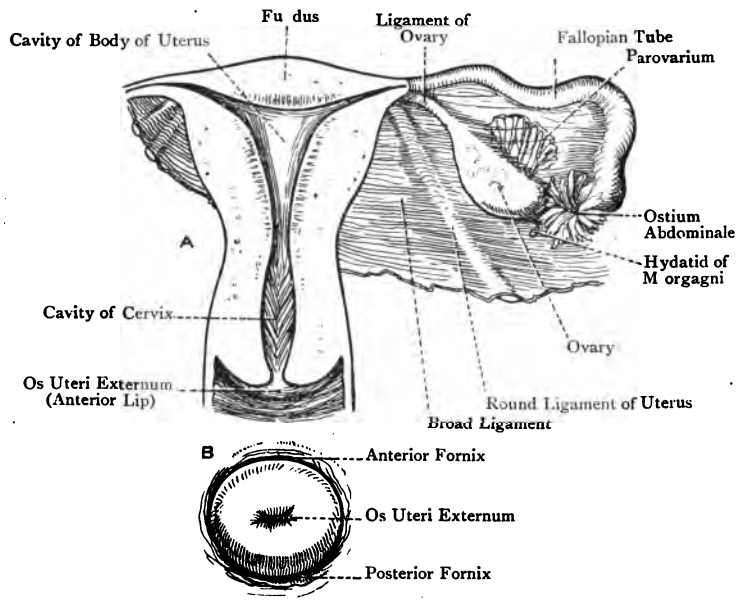


FIG. 359.—THE UTERUS AND ITS APPENDAGES.

A, The Uterus opened, and the Right Broad Ligament (Posterior View); B, The Os Uteri Externum.

weight is about 2 drachms. It presents two surfaces, two borders, and two extremities.

The **surfaces** are laterally disposed, and are called *internal* or *mesial*, which is related to the Fallopian tube, and *external* or *lateral*, which is related to the ovarian fossa. The **borders** are anterior and posterior. The *anterior* or *attached border* is straight. Along it are attached the two layers of the mesovarium, and between these it presents a hilum for the passage of the blood-vessels, nerves, and lymphatics. The *posterior border* is convex and free. The extremities are named **poles**, superior and inferior respectively. The *superior* is named the *tubal pole*, because the

ovarian fimbria is attached to it. Connected with it there is also a fold of peritoneum, which passed upwards to join the peritoneum over the psoas magnus near the upper part of the external iliac vessels. This fold, which is termed the *suspensory ligament of the ovary*, is continuous with the outer part of the broad ligament, and contains the ovarian vessels and nerves. The *inferior* pole is known as the *uterine pole*, and is connected with the superior angle of the uterus by a round cord, called the *ligament of the ovary*. The attachment of this ligament to the uterus is behind and a little below the uterine end of the Fallopian tube.

The surface of the ovary is covered by peritoneum, continuous with the mesovarium, the only exception being along the anterior border, where the hilum exists. The connective-tissue element of this peritoneum is inseparably blended with the so-called tunica albuginea of the ovary, and it is covered by an epithelium the cells of which present a striking contrast to those of the endothelial covering elsewhere. It is composed of *short columnar cells*, and imparts a somewhat dull appearance to the surface, which contrasts with the polished appearance elsewhere. The ovarian epithelium is the remains of the germinal epithelium, from which the ovary is developed, and at the circumference of the organ it passes abruptly into the endothelial cells of the adjacent peritoneum. Prior to puberty the surface of the ovary is smooth, but after that period it gradually assumes a pitted and scarred appearance, which is due to the periodical escape of the ova from the Graafian follicles.

Descent of the Ovary.—The ovary, like the testis, lies originally upon the psoas magnus, below and behind the kidney. At the period of birth it is found lying at the pelvic brim, partly in the iliac fossa and partly in the pelvis.

Abnormal Positions of the Ovary.—(1) The ovary, in its original descent, may pass into the inguinal canal, and even into the labium majus; (2) it may pass through the crural ring into the crural canal, and lie over the saphenous opening, where it may simulate a femoral hernia; (3) an ovary, when enlarged, may become prolapsed, and pass downwards and inwards behind the uterus into the pouch of Douglas, where it may be palpated through the posterior fornix of the vagina.

For the structure and development of the ovary, see p. 836 *et seq.*

Epoöphoron (Parovarium of Kobelt), or Organ of Rosenmüller.—The epoöphoron is situated in that portion of the mesosalpinx which lies between the ovary and the Fallopian tube. It is composed of a number of small blind tubules, lined with epithelium, which converge towards the ovary, but do not meet. Their tubal ends are united by a longitudinal tube, which lies parallel with, and a little below, the Fallopian tube.

Paroöphoron of Waldeyer.—The paroöphoron is situated in that part of the mesosalpinx which lies between the ligament of the ovary and the Fallopian tube, where it is placed near the uterus. It is composed of a few minute blind tubules, which can only be discerned at or shortly after the period of birth.

For the development of the epoöphoron and paroöphoron, see p. 839.

Fallopian Tubes.—The Fallopian tubes, right and left, serve to convey the ova, after their escape from the Graafian follicles, into the cavity of the uterus. They are, therefore, functionally the ducts of the ovaries, and are hence spoken of as the *oviducts*. Each tube is contained within the superior border of the broad ligament, except at its extreme inner end, where the tube is embedded in the uterine wall. It is fully 4 inches in length. Proceeding from the uterus, it passes at first horizontally outwards for about 1 inch towards the lower or uterine pole of the ovary. It then ascends vertically for a short distance upon the lateral wall of the pelvis, where it lies internal to the anterior or attached border of the ovary. Having arrived at the upper or tubal pole, it arches backwards and descends along the posterior convex border, and adjacent portion of the internal surface of the ovary. Each Fallopian tube is divided into the following parts: pars uterina, isthmus, ampulla, neck, and corpus fimbriatum; and each has two openings, ostium uterinum, and ostium abdominale.

The *pars uterina* is the limited portion which is contained within the uterine wall at the superior angle, and it presents the *ostium uterinum*, which is about 1 millimetre in diameter. The *isthmus* succeeds to the pars uterina, and represents about one-third of the tube. It is straight, round, and firm to the touch, due to the predominance of circular muscular fibres in this portion. Its diameter is about 2½ millimetres. The *ampulla* succeeds to the isthmus, and forms rather more than half of the tube. It is larger than the isthmus, less resistant (being chiefly mucous in structure), and tortuous. Its diameter gradually increases in the distal direction, the average being about 7 millimetres. The ampulla at its outer end becomes constricted to form the *neck*, which presents the *ostium abdominale*, opening into the pelvic cavity, its diameter being about 2 millimetres. It is in this situation where the general cavity of the peritoneum in the female is continuous with the lumen of the Fallopian tube, and through it with the cavity of the uterus and vagina. Beyond the neck the tube expands in the form of a funnel, called the *infundibulum* or *pavilion*, in the body of which the ostium abdominale is situated. The circumference of the infundibulum is broken up into a number of irregular fringes, called *fimbriæ*, and the outer end of the tube is hence called the *corpus fimbriatum*. The larger fimbriæ are broken up into smaller filiform processes. The outer surfaces of the fimbriæ, which look into the pelvic cavity, are covered by peritoneum, but the inner surfaces, which look into the infundibulum, are covered by mucous membrane continuous with that of the Fallopian tube. At the free margins of the fimbriæ the peritoneum, with its endothelial cells, becomes continuous with the mucous membrane, which is covered by ciliated columnar epithelium. One of the fimbriæ, which is

larger and longer than the others, is called the *ovarian fimbria*, and is connected with the upper or tubal pole of the ovary usually directly, but sometimes by a delicate fibrous band. This fimbria presents a longitudinal furrow, which serves as a channel of communication between the ostium abdominale and the ovary.

For the structure and development of the Fallopian tubes, see pp. 839 and 842.

Hydatids of Morgagni.—These are small pedunculated cysts, sometimes solitary, which are connected with the fimbriæ, the outer end of the ampulla, or the epoöphoron. They are vestiges of the anterior or cephalic end of the Wolffian duct.

Uterus.—The uterus is a hollow muscular organ, which receives at its superior angles the Fallopian tubes, and opens below into the upper part of the anterior wall of the vagina. Through the Fallopian tubes it receives the ova at periodical intervals, and, when an ovum becomes impregnated, the uterus retains it during development, and thereafter expels the fœtus through the vagina. The virgin uterus lies upon the superior surface of the bladder, and is usually inclined to the right of the middle line. Above it there are a portion of the pelvic colon and usually a few coils of the ileum. At its lower end is the vagina, and the broad ligament stretches from either side. It is somewhat pyriform, the wide end being directed upwards and forwards, and is flattened from before backwards. It is firm and resistant to the touch, on account of its very thick muscular walls. Its average length is 3 inches, the breadth at the upper part being 2 inches, and the thickness 1 inch. The organ is divided into a fundus, body, and cervix.

The **fundus** is that portion which lies above the level of a line connecting the superior angles, where the Fallopian tubes pass through the uterine wall. It is convex from side to side, and also from before backwards. The lateral borders of the uterus are sloped downwards and inwards, and at the junction of the upper two-thirds and lower third of the organ there is a slight constriction or concavity, called the *isthmus*, which is also present in front and behind, and is most conspicuous in early life. The part between the fundus and the isthmus is the body, and the part below the isthmus is the cervix.

The **body,** which is 2 inches long, is triangular, and presents two smooth surfaces, anterior and posterior, and two lateral borders. The *anterior* or *vesical surface*, which has an inclination downwards, is slightly convex. The *posterior* or *rectal surface*, which has an inclination upwards, is more markedly convex. Each *lateral border* extends from the superior angle to the isthmus, and is sloped downwards and inwards. The *superior angles* are situated at the points of entrance of the Fallopian tubes, and correspond with the portions of the uterus which are elongated into cornua in some animals.

The **cervix,** which measures 1 inch in length, is cylindrical, and narrower than the body. It is received into the upper part of the anterior wall of the vagina, the walls of which are at-

tached to it in such a manner as to divide it into two portions—supravaginal and vaginal. The posterior wall of the vagina extends higher upon the cervix behind than the anterior wall does in front. The anterior surface of the supravaginal portion, which is about ½ inch in extent, is related to the base of the bladder, with the intervention of some loose cellular tissue. The posterior surface of the supravaginal portion, which is about ¼ inch in extent, forms a part of the anterior wall of the pouch of Douglas, and is crossed transversely by the torus uterinus. At the lower end of the vaginal portion, where the cervix is slightly protuberant, there is an opening, called the **os uteri externum,** through which the cavity of the cervix communicates with that of the vagina. This opening is also known as the *os tincæ*, because it is supposed to resemble the mouth of the tench fish, on account of its lips being of unequal size. In early life this opening is circular, but later, in the virgin, it assumes the form of a transverse slit about ½ inch long. It is bounded by two lips, anterior and posterior, which in the virgin are smooth, but in multiparæ they are often more or less fissured, especially the posterior lip. The *anterior lip* is thick, round, and short, whilst the *posterior* is thin, sharp, and long. The anterior lip descends lower into the vagina than the posterior, by reason of the oblique manner in which the cervix uteri passes into the canal. It is the anterior lip which first meets the finger in making vaginal examinations. The greater length of the posterior lip is due to the fact that the posterior wall of the vagina extends higher on the back of the cervix than the anterior wall does in front. The os uteri externum is directed downwards and backwards towards the posterior wall of the vagina, this being due to the oblique position of the cervix.

Surrounding the vaginal portion of the cervix there is a vaulted recess, which is divided into anterior, posterior, and lateral **fornices.**

General Relations of the Uterus.—The anterior surface of the body rests upon the superior surface of the bladder, and the anterior surface of the supravaginal portion of the cervix is related to the base of the bladder. The lateral relations are the Fallopian tubes, round ligaments, ligaments of the ovaries, broad ligaments, and a certain amount of adipose tissue, containing large bloodvessels, which lies upon either side of the cervix, and extends upwards over the lateral border between the layers of the broad ligament. This collection is known as the **parametrium.** The posterior surface of the body is related to the rectum, and the posterior surface of the supravaginal portion of the cervix forms a part of the anterior boundary of the pouch of Douglas.

Peritoneal Relations.—The following parts of the uterus are covered by peritoneum: the supravaginal portion of the cervix posteriorly, the posterior surface of the body, the fundus, and the anterior surface of the body as low as the front of the cervix. The following parts are free from peritoneal covering: the vaginal portion of the cervix, the supravaginal portion of the cervix

anteriorly, and a narrow strip along each lateral border where the two layers of peritoneum pass off to form the broad ligament. The uterine peritoneal folds are as follows: two utero-vesical, sometimes called the anterior uterine ligaments, but they may also be regarded as the posterior false ligaments of the bladder; the sacro-uterine folds, with the torus uterinus; and the broad ligaments.

Position of the Uterus.—The virgin uterus occupies a position of anteflexion and anteversion, assuming the bladder and rectum to be empty. In speaking of the uterus as being *anteflexed* it is to be understood that the body of the organ is bent forwards at the isthmus in such a manner that it forms with the cervix an angle, which is open anteriorly. This is brought about in the following manner: the cervix uteri is more fixed than the body, from its connection with the vaginal walls and base of the bladder; and the cervix is less yielding than the body. In speaking of *anteversion* of the uterus it is to be understood that the entire uterus is inclined forwards, so that its long axis forms an angle with the longitudinal axis of the trunk. The anterior surface has therefore a downward inclination towards the superior surface of the bladder, and the posterior surface has an upward inclination, and so supports a portion of the pelvic colon and a few coils of the ileum. When the bladder is distended, the position of the uterus becomes altered. The organ is raised along with the distended bladder, the anteflexion and anteversion become less, and the uterus may even assume a vertical position. Any coils of the ileum lying in contact with its posterior surface, as well as the pelvic colon, would be displaced, and the organ would come to be closely related to the rectum.

Interior of the Uterus.—The interior is divided into two portions, —the cavity of the body and the cavity of the cervix. The *cavity of the body* is very small compared with the thickness of the uterine walls, and is triangular, with the base directed upwards towards the fundus. Its three sides are convex towards the cavity, and its anterior and posterior walls are in contact. In the vicinity of each superior angle it narrows, and gradually tapers to the ostium uterinum of the Fallopian tube, with the lumen of which it is continuous. Inferiorly the cavity also becomes narrow, and, at the junction of the body and cervix, it ends in a circular opening, called the **os uteri internum,** which is smaller than the os externum. Through this opening it becomes continuous with the cavity of the cervix. The *cavity of the cervix* is spindle-shaped, being wider at the centre than at either end. It is somewhat flattened from before backwards, and is continuous above with the cavity of the body through the os internum, and below with the cavity of the vagina through the os externum. Its mucous membrane presents two longitudinal ridges, anterior and posterior, from each of which a number of rugæ extend in an upward and outward direction, the appearance thus produced being known as the *arbor vitæ uterina*, or *plicæ palmatæ*.

Uterus at Birth.—At birth the neck of the uterus is larger than the body, and there is no fundus. At each superior angle it tapers very much, and resembles somewhat a uterus bicornis. The arbor vitæ uterina extends all along the interior.

Varieties.—These are as follows : (1) uterus bicornis ; (2) uterus unicornis ; and (3) double uterus.

For the structure and development of the uterus, see pp. 840 and 842.

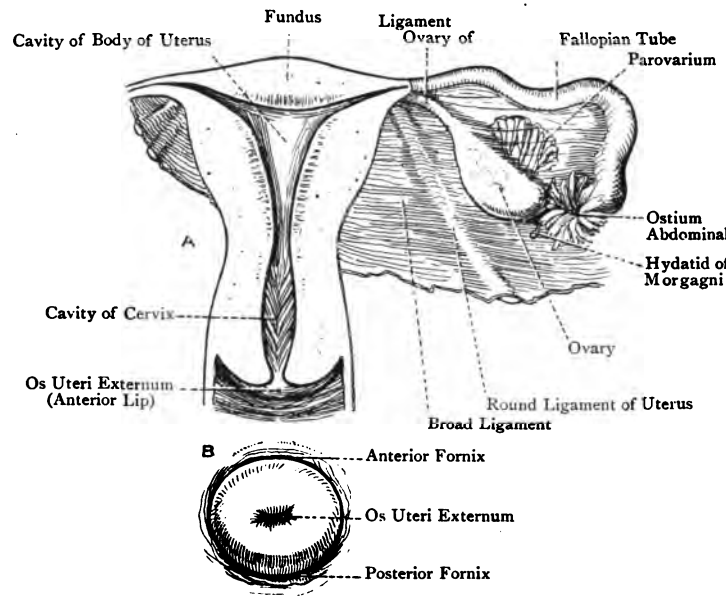


FIG. 360.—THE UTERUS AND ITS APPENDAGES.

A, The Uterus opened, and the Right Broad Ligament (Posterior View) ; B, The Os Uteri Externum.

Vagina.—This is a musculo-membranous passage which extends from the cervix uteri to the vulva. It is from 3 to 3½ inches long, being 3 inches along the anterior wall, and 3½ inches along the posterior. It is slightly curved, and its direction is downwards and forwards. Its axis forms an obtuse angle with that of the uterus (100° to 110°). In the erect posture it forms with the horizontal an angle of about 60°. Superiorly it is closely connected with the cervix uteri, the posterior wall rising higher than the anterior. It is rather narrower at either end than at the centre, the lower end being the narrowest part of the passage. The walls are anterior and posterior, and they are in contact. In transverse section the vagina appears as an H-shaped fissure at its

lower end, as a transverse fissure at the centre, and at its upper end it presents a lumen which is almost circular.

Relations—*Anterior.*—The base of the bladder, and the urethra. *Posterior.*—From above downwards there are the pouch of Douglas for a short distance, the rectum, with the intervention of the recto-vaginal lamina of the visceral pelvic fascia, and the anal canal, from which it is separated by the perineal body. The posterior wall is covered by peritoneum over about its upper fourth. *Lateral.*—The ureter at the upper end for a short distance, and the levatores ani muscles.

The vagina passes through the triangular ligament, and its lower end has a bulbus vestibuli on either side, with the sphincter vaginæ surrounding the external orifice. When the finger is passed into the posterior fornix, which is the recess between the posterior lip of the os uteri externum and the posterior wall of the vagina, the pouch of Douglas can be palpated, and a few coils of the ileum, or a prolapsed ovary, may be felt in it. The base of the bladder may be palpated through the anterior fornix, and the urethra through the anterior wall of the vagina lower down.

For the structure and development of the vagina, see p. 842.

Bladder.—The base is directed backwards, and is related to the front of the supravaginal portion of the cervix uteri and a portion of the anterior wall of the vagina, the utero-vesical pouch of the peritoneum intervening. The superior surface is in contact with the anterior surface of the body of the uterus. The false ligaments, formed by the peritoneum, are at least three in number, namely, one superior and two lateral. The peritoneal folds on either side of the utero-vesical pouch are usually regarded as the anterior uterine ligaments, but they may also be looked upon as the posterior false ligaments of the bladder. The true ligaments are similar in both sexes.

Ureters.—Each ureter lies for a short distance on the side of the cervix uteri and upper part of the wall of the vagina, being crossed near the cervix by the uterine artery.

Urethra.—The urethra is very closely related to the anterior wall of the vagina. Its length is 1½ inches, and its transverse diameter is about ¼ inch, the narrowest part being at the meatus urinarius. The direction of the canal is downwards and forwards, and its walls are anterior and posterior, these being in contact except during micturition. In its course it passes between the two layers of the triangular ligament, where it is embraced by the compressor urethræ muscle. The canal is capable of considerable distension, and may, under anæsthetics, admit the index-finger. The *meatus urinarius* is situated at the posterior extremity of the vestibule in the middle line, immediately in front of the external orifice of the vagina, and is placed on a slight prominence, the margins of which are somewhat irregular.

For the structure and development of the urethra, see p. 843.

Rectum—Relations—*Anterior.*—The uterus and vagina, the recto-vesical pouch of Douglas intervening for a short distance in the vicinity of the cervix uteri. *Posterior.* — As in the male.

Anal Canal.—This is separated from the vagina by the perineal body.

Ovarian Artery in the Pelvis.—This vessel, which arises from the abdominal aorta about 1 inch below the renal artery, enters the pelvis by crossing the commencement of the external iliac. It then passes within the broad ligament of the uterus, where it is very tortuous, and its branches to the ovary enter that organ through the hilum on the anterior border without piercing the peritoneum. Besides supplying the ovary the vessel furnishes the following branches: *uterine* to the uterus, near the superior angle, where it anastomoses with branches of the uterine artery from the internal iliac; *tubal* to the Fallopian tube; and *ligamentous* to the round ligament of the uterus, which accompanies it as far as the inguinal canal.

The **ovarian vein** of each side originates as two vessels in the **ovarian** or **pampiniform plexus,** which lies within the broad ligament. This plexus receives the veins which emerge through the hilum of the ovary, as well as tributaries from the Fallopian tube and round ligament of the uterus, and it communicates freely with the uterine plexus. The two ovarian veins, having emerged from the ovarian plexus, leave the pelvis, and soon join to form a single vein, that of the *right* side opening into the inferior vena cava, and that of the *left* side into the left renal vein.

Uterine Artery.—This vessel is derived from the anterior division of the internal iliac artery. It is directed downwards and inwards to the side of the cervix uteri, near which it crosses the ureter. On reaching the cervix it turns upwards along the lateral border of the body in a very tortuous manner, lying between the two layers of the broad ligament. As it ascends it gives off tortuous branches to the front and back of the body, and near the inner end of the Fallopian tube it anastomoses with the uterine branch of the ovarian artery. Along the side of the body it also gives offsets to the round ligament, ligament of the ovary, and Fallopian tube. At the cervix the uterine artery furnishes two branches—cervical and vaginal. The *cervical branch* supplies offsets to the cervix. One of these, called the *coronary artery*, divides into two branches, which with their fellows of the opposite side form an arterial circle around the cervix. The *vaginal branch* divides into two, anterior and posterior, which descend in the middle line of the anterior and posterior walls of the vagina, where they anastomose with branches of the vaginal arteries.

The **uterine veins,** which are destitute of valves, form a copious plexus within the broad ligament close to the uterus, where it is embedded in the parametrium. The blood from the lower part

of this plexus is conveyed away by two uterine veins, which are tributaries of the internal iliac vein. A large proportion of the blood, however, passes from the upper part of the plexus into the ovarian plexus. The uterine plexus communicates below with the vaginal plexus.

Vaginal Artery.—This vessel, which usually replaces the inferior vesical of the male, arises from the anterior division of the internal iliac, occasionally in common with the uterine, or the middle hemorrhoidal, artery. It passes downwards and inwards to the wall of the vagina, where it divides into branches which anastomose with their fellows of the opposite side, the vaginal branches of the uterine

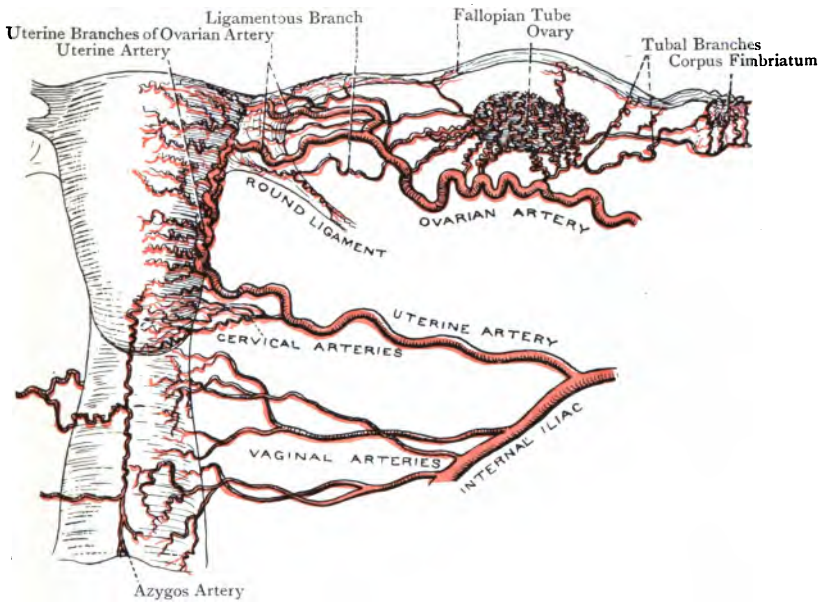


FIG. 361.—THE OVARIAN, UTERINE, AND VAGINAL ARTERIES. (POSTERIOR VIEW) (AFTER HYRTL).

arteries, and, towards the lower end of the vagina, with branches of the internal pudic. Along the anterior and posterior walls, in the median line, an arterial chain is constructed by the vaginal arteries and the vaginal branches of the uterine arteries, thus forming the vessels known as the *vaginal azygos arteries*. The vaginal artery also furnishes branches to the bladder, rectum, and bulbus vestibuli.

The veins of the vagina form a rich plexus in the muscular coat, which is more copious towards the lower end. They communicate above with the uterine plexus, in front with the pudendal plexus

around the urethra, behind with the hemorrhoidal plexus, and below with the veins of the bulbus vestibuli. The **vaginal vein** leaves the upper part of the vaginal plexus and opens into the internal iliac vein.

THE STRUCTURE OF THE SPECIAL VISCERA OF THE FEMALE PELVIS.

The Ovaries.

The ovary is covered by a layer of short columnar epithelial cells. These are the remains of the germinal eptihelium from which the organ is developed, and they rest upon a delicate, connective-tissue membrane, which is blended with the so-called tunica albuginea. Interposed between the columnar cells there are a few spheroidal cells of larger size, which are primordial ova. The connective-tissue membrane is continuous with the peritoneum which forms the mesovarium along the margins of the hilum, and which is covered by endothelium. Within this membrane, and blended with it, there is a continous covering, consisting of fibrous connective tissue, which is called the *tunica albuginea ovarii*, from its supposed resemblance to the tunica albuginea testis. It is, however, really a condensation of the ovarian stroma at the surface. This stroma pervades the interior of the ovary, and is composed of fibrous connective tissue, which is richly provided with spindle-shaped cells and elastic tissue. There are also a few plain muscular fibres in the deeper part of the ovary close to the hilum. The spindle-shaped cells are regarded by some authorities as muscular fibre-cells, but they probably belong to the connective tissue of the stroma. The stroma is freely permeated by bloodvessels, and contains the Graafian follicles. Immediately within the surface there is a layer of the stroma which presents a granular appearance, especially in young persons, due to the presence of an immense number of Graafian follicles, with their contained ova, in an early stage. This part of the ovary is called the *cortex*, the remainder being known as the *medulla*. Lying more deeply in the stroma there is another set of Graafian follicles, less numerous, but of larger size, these being in a more advanced stage. Still more deeply there is another and less numerous set of follicles, of still larger size, which are almost in a state of maturity. When these latter have attained full development, they pass towards the surface, where they may sometimes be seen as clear follicles causing slight projections. When fully developed, they attain a diameter of about $\frac{1}{12}$ inch. At periodical intervals one or more of these mature follicles rupture, this being accompanied by the discharge of a fluid—the liquor folliculi—and the simultaneous escape of the contained ovum or ova. After the discharge of its contents the follicle becomes filled with blood and cellular tissue, and assumes a yellow colour.

It is then known as a *corpus luteum*. This undergoes atrophy in the virgin, and, assuming a white colour, is known as a *corpus albicans*.

Structure of the Graafian Follicles.—The smallest follicles near the surface, which are about $\frac{1}{100}$ inch in diameter, consist of a single investing layer of flattened cells, closely embracing the contained ovum. It is computed that the ovaries of a child at birth contain as many as 70,000 of these follicles. In follicles a little more advanced the investing epithelium becomes columnar, and is arranged in two layers—outer and inner, the latter surrounding the ovum. In more mature follicles fluid, called the *liquor folliculi*,

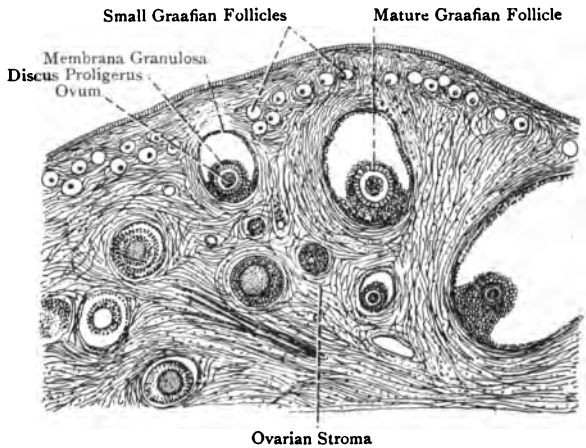


FIG. 362.—SECTION OF THE OVARY, SHOWING ITS MINUTE STRUCTURE.

accumulates between the outer and inner cellular layers, except at the point where the ovum lies. The outer layer is then known as the **membrana granulosa,** and the inner as the **discus proligerus.** The cells of these two layers become continuous at the part where the liquor folliculi is absent, so that in this manner the ovum is anchored to one point of the wall of the follicle. In the most mature follicles the liquor folliculi has increased in amount, and the cells of the membrana granulosa and discus proligerus have multiplied so as to form several strata. Each of these follicles has a distinct wall, called the *theca folliculi*, which is formed by a condensation of the surrounding stroma, and in which two layers can be recognised—an outer fibrous and an inner vascular. There is usually only one ovum in each follicle.

Structure of the Ovum.—The ovum is a spherical cell, having a diameter of about $\frac{1}{125}$ inch. It has two membranes—an external, called the **zona radiata** (zona pellucida), and an internal, called the **vitelline membrane,** the latter representing the cell-wall. Within

this is the cell-body, called the **yolk**, or **vitellus,** which contains a nucleus, known as the **germinal vesicle,** and that in turn contains a nucleolus, called the **germinal spot.** The zona radiata is fairly thick, and is perforated by pores or canals, arranged in a radiating manner, hence the name 'radiata.' These canals serve for the passage of nutritive material, and also for spermatozoa preparatory to impregnation. The vitelline membrane is merely a condensation of the yolk at the surface. The yolk, or vitellus, is semifluid, very refracting, and contains many yolk granules, which are fatty and albuminoid in their nature. These granules form the *nutritive yolk*, or *deutoplasm*, the remainder of the yolk being called the *formative yolk*, or *cytoplasm*. The nucleus or germinal vesicle is about $\frac{1}{300}$ inch in diameter. It is eccentric in position in the cytoplasm, and has the usual characters of a cell-nucleus. The nucleolus, or germinal spot, is granular in character.

Blood-supply of the Ovary.—The ovary receives its blood from the ovarian artery.

Nerves.—These come from the ovarian sympathetic plexus, which derives its fibres from the renal and aortic plexuses, and accompanies the ovarian artery.

Lymphatics.—The lymphatics of the ovary, along with those of the upper part of the uterus, pass to the *median lumbar glands*.

The ovaries represent the testes in the male, and they have been called the *testes muliebris*.

Ligament of the Ovary.—This is composed of plain muscular and fibrous tissues, the former being continuous with the muscular tissue of the uterus. It derives its blood-supply from the ovarian artery, and represents the upper part of the gubernaculum testis in the male fœtus.

Development of the Ovary.—The ovary, like the secreting tubules of the testis, is developed from the germinal epithelium and genital ridge. The **germinal epithelium** is developed from the peritoneal epithelium on the inner side of the Wolffian body, which latter epithelium undergoes a thickening and segmentation. This germinal epithelium covers a ridge of mesoblast, called the **genital ridge.** In the development of the ovary the germinal epithelium becomes much thickened, and some of the more deeply placed cells in the course of the second month invade the mesoblast of the genital ridge, where they become enlarged, and lie at first isolated in its mesoblastic connective tissue. These cells are the primordial ova. Other cells of the germinal epithelium now invade the genital ridge, where they arrange themselves in circular groups or 'cell nests' around the primordial ova. In this manner the primordial Graafian follicles are formed. The primordial ovum in the centre of each cell-nest represents the ovum of the mature Graafian follicle, the cells surrounding it represent the cells of the mature follicle, and the adjacent mesoblastic connective tissue represents the capsule of the follicle. From this period (second month) up to the seventh month other cells of the germinal epithelium continue to invade the genital ridge, where they at first form cell-columns, called the **egg-tubes of Pflüger.** At the same time bands of the mesoblastic connective tissue of the genital ridge between the egg-tubes invade the germinal epithelium, and this intermingling of egg-tubes and connective-tissue bands, together with the primordial Graafian follicles, gives rise to the ovary. The egg-tubes now break

up and form other cell-nests, and one cell of each nest in the centre becomes an ovum. These fresh cell-nests, with their contained ova, form other Graafian follicles. Sometimes two or three ova are formed within a cell-nest. The capsular investment of the ovary is developed from the mesoblastic connective tissue of the genital ridge, which becomes condensed at the surface to form an external tunic. The permanent epithelium of the ovary is developed from the surface cells of the germinal epithelium which have not taken part in the formation of the ova and egg-tubes. The cells of this epithelium differ in a marked manner from those of the adjacent peritoneum inasmuch as they are *columnar*, whilst the cells of the adjacent peritoneum are the usual *flattened endothelial cells* of a serous membrane.

Summary.—The Graafian follicles, with their contained cells and ova, are developed from the cells of the germinal epithelium. The capsules of the follicles and the external tunic of the ovary are developed from the mesoblastic connective tissue of the genital ridge. The permanent epithelium, which covers the surface of the ovary, and is composed of short columnar cells, is developed from the surface cells of the germinal epithelium which have not taken part in the formation of the Graafian follicles.

Development of the Epoöphoron.—The **longitudinal tube,** which lies parallel to the Fallopian tube, is a persistent part of the Wolffian duct, and represents the canal of the epididymis in the male. In some animals, *e.g.*, the sow, the Wolffian duct remains persistent, and, under the name of the *duct* or *canal of Gärtner*, can be traced from the broad ligament of the uterus along the side of that organ to the lateral wall of the vagina in its upper part, where it disappears. In the human female it sometimes takes a similar course, and the portion of it on the uterine and vaginal walls is to be regarded as representing the vas deferens in the male. When a persistent Wolffian duct takes this course in the human female, it is sometimes spoken of as the duct of Gärtner. The **transverse tubules** of the epoöphoron, extending from the region of the ovary to the longitudinal tube (so-called duct of Gärtner), into which they open at right angles, are vestiges of the anterior segmental tubes of the Wolffian body, and represent the vasa efferentia and coni vasculosi of the testis in the male.

Development of the Paroöphoron.—These vestigial tubules are derived from the more posterior segmental tubes of the Wolffian body, and they represent the paradidymis or organ of Giraldés in the male.

Structure of the Fallopian Tubes.

The wall of the **Fallopian tube** is composed of four coats—serous, muscular, submucous, and mucous. The **serous coat** is formed by the peritoneum. The **muscular coat** is composed of plain muscular tissue, arranged as an *outer longitudinal* and *inner circular layer*, the latter being the thicker. The **submucous coat** is areolar in structure. The **mucous coat** is continuous with that of the uterus on the one hand, and with the peritoneum on the other, at the margins of the fimbriæ. It is thrown into longitudinal folds, which are simple in the isthmus, but complex in the ampulla, where they are beset with secondary folds, and communicate in such a manner as to give rise to alveolar spaces, thus imparting an almost glandular appearance to the coat. In transverse section the tube presents a branched lumen, which is nearly filled by the leaf-like processes formed by the mucous folds. The mucous membrane is covered by ciliated columnar epithelium, which, at the free margins of the fimbriæ, passes into the endothelium of the peritoneum.

Blood-supply.—The ovarian and uterine arteries.

Nerves.—These are derived from the ovarian and uterine sympathetic plexuses.

Lymphatics.—These pass to the *median lumbar glands* along with those of the ovary and upper part of the body of the uterus.

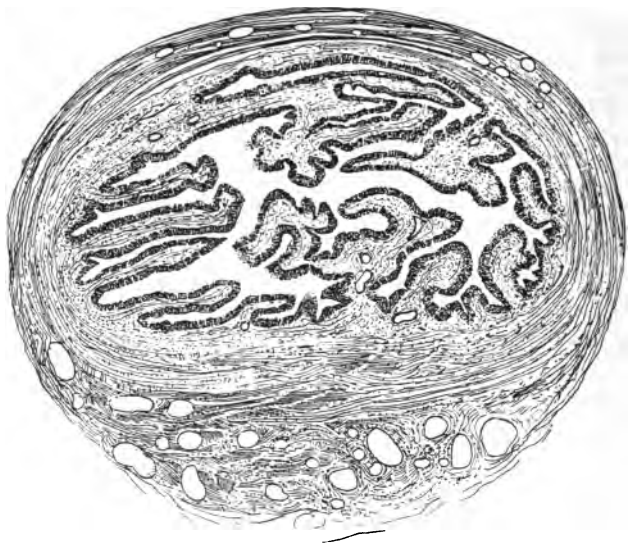


FIG. 363.—TRANSVERSE SECTION OF THE FALLOPIAN TUBE (HIGHLY MAGNIFIED).

Structure of the Uterus.

The wall of the uterus consists of three coats—serous, muscular, and mucous—there being no submucous coat.

The **serous coat** is formed by the peritoneum, already described.

The **muscular coat** is composed of plain muscular tissue, with an admixture of areolar tissue, and it imparts great thickness to the wall. The muscular tissue is disposed in three strata—outer, middle, and inner. The *outer stratum* is thin, and its fibres are disposed longitudinally over the front and back of the organ, becoming continuous with one another by turning over the fundus. Those nearest the lateral borders incline outwards, and are prolonged into the round ligaments, Fallopian tubes, and ligaments of the ovaries. Some from the back of the supravaginal portion of the cervix are prolonged into the sacro-uterine folds. The *middle stratum* is very thick, and is composed of fibres which interlace in a complex manner over the body, but in the neck they are arranged circularly. The bloodvessels and nerves are freely interspersed

throughout this layer. The *inner stratum*, which is also very thick, has its fibres disposed longitudinally in the cervix. As they ascend over the body they become oblique, and at the superior angles they run circularly. The uterine glands project into this stratum, and it contains a free admixture of areolar tissue. It is right to mention that the inner stratum is regarded as a very much thickened muscularis mucosæ, according to which view it would form a part of the mucous coat (Williams).

The **mucous membrane** of the *cavity of the body* is smooth, and soft in consistence, and is covered by ciliated columnar epithelium. It is beset with a number of openings, which are the mouths of the **uterine** or **utricular glands.** These are simple tubular glands, which extend in a somewhat convoluted manner through the entire thickness of the mucous coat, and project by their deep blind ends into the inner muscular stratum, there being no submucous coat. Each gland is composed of a basement membrane, which is lined with ciliated columnar epithelium, continuous with that of the cavity of the body. Each has a distinct lumen, except at its deep end, where it is filled with cells. The mucous membrane of the *cavity of the cervix* is of firmer consistence than that of the cavity of the body, and, as has been stated, it presents the appearance known as the arbor vitæ uterina. It is provided with papillæ, and is covered by *columnar epithelium*, except near the os externum, where the epithelium is of the *stratified squamous* variety, as it is over the exterior of the vaginal portion of the cervix and vagina. On the summits of the rugæ the columnar cells are ciliated, but in the furrows between them they are devoid of cilia. The mucous membrane is freely provided with **racemose glands,** which in the upper part of the cervix are lined with columnar cells, and in the lower part with cubical cells. In both regions the cells are non-ciliated. The glands in the lower part of the cervix have each a large lumen, and they secrete a very tenacious mucus during pregnancy, which, in the later stages of that period, plugs the os externum.

In addition to these glands clear vesicles of a yellowish colour, called the **ovula Nabothi,** may be seen in the mucous membrane between the rugæ of the arbor vitæ uterina, which are supposed to result from the closure of some of the racemose glands.

Blood-supply.—The uterus is supplied with blood by the uterine arteries, and the uterine branches of the ovarian arteries.

Nerves.—The chief nerves are derived from the uterine sympathetic plexus, which is an offshoot from the pelvic plexus, and accompanies the uterine artery. It is to be noted that the pelvic plexus contains spinal fibres derived from the third and fourth sacral nerves (sometimes also the second), and from the upper two or three lumbar nerves, as in the case of the bladder and rectum. The uterus also receives sympathetic fibres from the ovarian plexus, which is derived from the renal and aortic plexuses.

Lymphatics.—These are very numerous, and form superficial and

deep sets. Those from the cervix and adjacent portion of the body pass to the *internal iliac glands*, whilst those from the upper portion of the body pass, with those of the ovaries and Fallopian tubes, to the *median lumbar glands*.

Structure of the Vagina.

The wall of the vagina is composed of three coats—fibrous, muscular, and mucous.

The **fibrous coat** is composed of dense connective tissue.

The **muscular coat** consists of plain muscular tissue, arranged as an *outer longitudinal* and *inner circular layer*, both being closely connected. Embedded in this coat there is a network of anastomosing veins, representing erectile tissue, which is well developed round the lower part of the passage. The plain muscular coat is replaced at the external orifice by the striated sphincter vaginæ muscle.

The **mucous membrane** is covered by stratified squamous epithelium, and is provided with papillæ. In the upper part of the passage it contains mucous glands. Along the middle line of the anterior and posterior walls it presents a ridge, these ridges being called the **columns** of the vagina, or *columnæ rugarum*. Passing off from them at right angles there are, in the virgin, numerous transverse rugæ, these appearances being well marked in the lower part of the passage, and absent in the upper part.

Blood-supply.—The vagina is supplied with blood by the vaginal arteries, the vaginal branches of the uterine arteries, and branches of the internal pudic arteries.

Nerves.—These are derived from the vaginal sympathetic plexus of each side, which is an offshoot from the pelvic plexus.

Lymphatics.—These form two networks, one in the mucous coat, and the other in the muscular coat, which communicate with each other. The lymphatics from the upper two-thirds pass to the *internal iliac glands*, whilst those from the lower third go to the *inguinal glands*.

Development of the Fallopian Tubes, Uterus, and Vagina.—These structures are developed from the Müllerian ducts, which appear shortly after the Wolffian ducts. Each Müllerian duct is developed from a part of the germinal epithelium. At first it takes the form of a solid longitudinal cord, which subsequently acquires a lumen, and it lies upon the outer side of, and parallel to, the corresponding Wolffian duct. The Müllerian ducts open by their anterior or cephalic ends into the cœlom or body-cavity. On being traced backwards they cross the Wolffian ducts and lie on their inner sides. They then enter the genital cord, which is a collection of connective tissue enclosing the Wolffian ducts as they pass to the cloaca. Within the genital cord the Müllerian ducts unite about the fourth month, and form one duct or canal, which occupies the median line. This duct finally opens into the lower portion of the ventral or uro-genital compartment of the cloaca, which subsequently forms the uro-genital sinus, its opening being in the median line between the openings of the Wolffian ducts. The anterior or cephalic parts of the Müllerian ducts retain permanently their openings into the cœlom or body-cavity, which are somewhat funnel-shaped, and these anterior parts give rise to the Fallopian tubes.

The tube or canal formed by the union of the posterior parts of the Müllerian ducts forms the uterus and the vagina.

In the male the only vestiges of the Müllerian ducts which are met with are the sinus pocularis (uterus masculinus) of the prostatic urethra, and the hydatids of Morgagni of the testis.

The abnormal condition of the uterus known as *uterus bicornis* (two-horned uterus) is due to the fact that the union of the two Müllerian ducts sometimes takes place lower down than usual. The condition known as *uterus unicornis* is due to imperfect development of one Müllerian duct. In extremely rare cases these ducts fail to unite, and, by opening independently into the uro-genital sinus, they give rise to a double uterus and double vagina. In the male the tube formed by the union of the posterior ends of the Müllerian ducts forms the sinus pocularis (uterus masculinus), which thus represents the uterus and vagina (Banks).

Structure of the Urethra.

The wall of the urethra is composed of three coats—muscular, vascular, and mucous. The **muscular coat,** which is continuous with that of the bladder, is composed of plain muscular tissue, arranged as an *outer circular* and an *inner longitudinal* layer. The circular fibres are well developed, especially at the upper end, where they partake somewhat of the nature of a sphincter muscle. Superficial to the circular fibres the urethra, as it lies between the two layers of the triangular ligament, is embraced by the striated fibres of the compressor urethræ. The **vascular coat** is composed of a rich plexus of veins, supported and pervaded by areolar and elastic tissues. This plexus is continuous above with that around the neck of the bladder. The **mucous coat** is covered by *transitional epithelium* in its upper part, and *stratified squamous epithelium* in its lower part. It is provided with papillæ, and is thrown into longitudinal folds, which are temporary above, but permanent below. One fold, situated on the posterior wall, is larger than the others, and is known as the **crest.** The mucous membrane is furnished with tubular mucous glands, and between the permanent folds in the lower part there are crypts or lacunæ.

The **lymphatics** of the urethra pass to the *inguinal glands.*

Development of the Urethra.—The female urethra is developed from the anterior or cephalic end of the ventral or uro-genital compartment of the cloaca, which also gives rise to the bladder. It represents the prostatic portion of the male urethra as low as the sinus pocularis or uterus masculinus.

The Articulations of the Pelvis.

Lumbo-sacral Articulation.—The union between the fifth lumbar vertebra and the base of the sacrum is effected by means of the following ligaments: an intervertebral disc, prolongations of the anterior and posterior common ligaments of the bodies of the vertebræ above, capsular ligaments and synovial membranes for the articular processes, ligamenta subflava for the laminæ, and interspinous and supraspinous ligaments for the spinous processes. These are similar to the corresponding ligaments above the level

of the fifth lumbar vertebra. The articulation between the bodies of the fifth lumbar and first sacral vertebræ belongs to the class **amphiarthrosis,** and the joints between the articular processes belong to the class **diarthrosis,** and the subdivision **arthrodia.** In addition to the foregoing ligaments there are two special ligaments, called lateral lumbo-sacral and ilio-lumbar. The **lateral lumbo-sacral ligament,** at either side, extends from the lower aspect of the transverse process of the fifth lumbar vertebra anteriorly to the upper surface of the ala of the sacrum at its anterior and outer part close to the sacro-iliac articulation. It is somewhat fan-shaped, and corresponds to the intertransverse ligaments of the lumbar vertebræ, and the superior costo-transverse ligaments of the thoracic region. The **ilio-lumbar ligament** extends from the tip of the transverse process of the fifth lumbar vertebra to the inner lip of the iliac crest, where it is attached for about 2 inches above the back part of the iliac fossa. It is triangular, and its direction is outwards and slightly backwards. It is closely associated with the lower part of the anterior lamina of the lumbar aponeurosis.

Arterial Supply.—Ilio-lumbar and superior lateral sacral arteries.

Nerve-supply.—Fourth and fifth lumbar nerves, and sympathetic filaments.

Movements.—Flexion, extension, and lateral movements between the opposed bodies, and gliding and rotation between the articular processes.

Sacro-coccygeal Articulation.—This belongs to the class **amphiarthrosis.** The bony elements are the fifth sacral and first coccygeal vertebræ. The opposed surfaces are transversely oval, and are separated by an intervertebral disc, unless in advanced life, when ankylosis takes place, this occurrence being earlier and more frequent in the male than in the female. The ligaments are as follows: **anterior** and **posterior sacro-coccygeal,** which are continuations of the anterior and posterior common ligaments of the bodies of the vertebræ; **supracornual,** which pass between the sacral and coccygeal cornua; and **intertransverse** or **lateral,** which pass between the inferior lateral angles of the sacrum and the transverse processes of the first coccygeal vertebra. The latter ligament is liable to become ossified.

Arterial Supply.—Inferior lateral and middle sacral arteries.

Nerve-supply.—Lower two sacral, and coccygeal, nerves.

Movements.—Forward and backward movements are allowed.

Intercoccygeal Articulations.—These only exist prior to middle life. The union between the coccygeal segments is effected by intervertebral discs, and anterior and posterior ligaments. The adjacent fibres of the great and small sacro-sciatic ligaments serve as lateral ligaments.

Sacro-iliac Articulation.—This belongs to the class **amphiarthrosis.** The bony elements are the auricular and ligamentous surfaces of the sacrum and ilium. The cartilage of the auricular surface is about $\frac{1}{12}$ inch thick, and it may be a single plate for both surfaces,

or it may exist as two plates, one for each surface, in which latter case a small synovial cavity exists between the two plates. When the bones are forcibly separated, a portion of the cartilage is usually left adherent to each auricular surface. The ligaments at the joint are anterior, posterior, and oblique. The **anterior sacro-iliac ligament** is composed of short fibres which are placed in front of the joint. The **posterior sacro-iliac ligament,** which is very strong, extends from the ligamentous surface of the ilium to the ligamentous surface of the sacrum and the transverse tubercles on the dorsum of the bone, the direction of the fibres being downwards and inwards. The **oblique sacro-iliac ligament** lies superficial to the posterior, and extends from the posterior superior iliac spine and the adjacent part of the iliac crest to the third and fourth transverse tubercles on the dorsum of the sacrum. It is really a detached part of the posterior sacro-iliac ligament. The great and small sacro-sciatic ligaments are accessory to this joint.

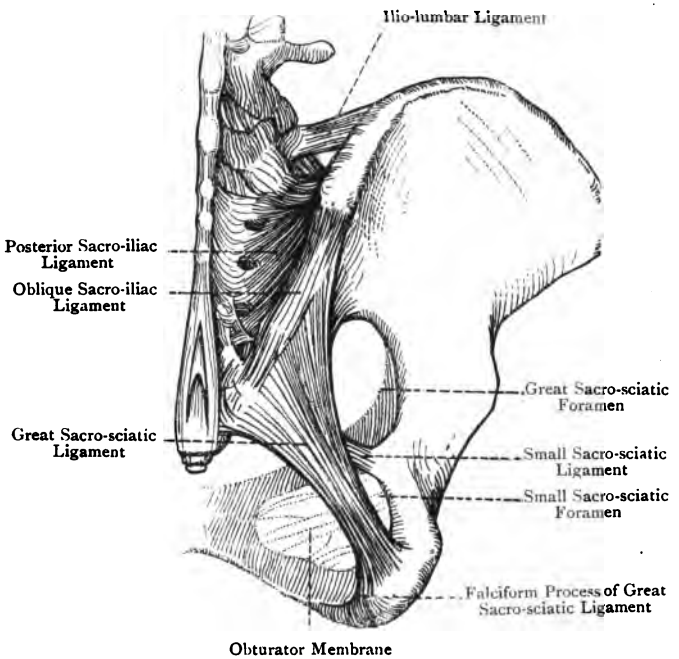


FIG. 364.—LIGAMENTS OF THE RIGHT HALF OF THE PELVIS (POSTERIOR VIEW).

The **great** or **posterior sacro-sciatic ligament** is attached by one extremity to the posterior inferior iliac spine, and the sides of the last three sacral and first coccygeal vertebræ, and by the other extremity to the inner border of the tuber ischii. From

this latter point it sends forwards an expansion, called the **falciform process,** which is attached to a sharp ridge on the lower part of the inner surface of the ramus of the ischium, close to its internal border. The ligament is broad at its attached ends, especially the upper, but in crossing towards the tuber ischii it becomes narrow. Its direction is downwards and forwards, and its ischial fibres are continuous with the tendinous origin of the long head of the biceps femoris. By its superficial surface it gives origin to part of the gluteus maximus, and resting on this surface are the plexiform loops formed by the external branches of the posterior primary divisions of the first three sacral nerves. Its deep surface gives origin to some fibres of the pyriformis, and lower down is intimately connected with the small sacro-sciatic ligament. The falciform process affords attachment to the lower part of the parietal pelvic fascia. The great sacro-sciatic ligament is pierced by the coccygeal branch of the sciatic artery, the sacral branch of the internal pudic artery, and the perforating cutaneous nerve from the sacral plexus. The ligament assists in the formation of the great and small sacro-sciatic foramina.

The great sacro-sciatic ligament is to be regarded as the separated tendon of the long head of the biceps femoris muscle.

The **small** or **anterior sacro-sciatic ligament,** which is triangular, is attached by its base to the sides of the last two sacral and first coccygeal vertebræ, where it is intimately connected with the more superficially placed great sacro-sciatic ligament. Its apex is attached to the tip of the spine of the ischium. Its deep surface is incorporated with the coccygeus muscle, and, along with the spine of the ischium, it forms the separation between the great and small sciatic foramina.

The small sacro-sciatic ligament is to be regarded as resulting from the fibrous degeneration of the superficial part of the coccygeus muscle.

Arterial Supply of the Sacro-iliac Articulation.—Ilio-lumbar, superior lateral sacral, and gluteal arteries.

Nerve-supply.—Superior gluteal, and anterior primary divisions, and external branches of the posterior primary divisions, of the first two sacral nerves.

Movements.—Stability being required at this joint, it is almost immovable. The two ossa innominata by their union at the pubic articulation form an arch, the convexity of which is directed downwards and forwards. The piers of this arch are separated by a wide interval, into which the sacrum fits in the form of a wedge. The sacrum being narrower behind than in front, the superincumbent weight of the trunk has a tendency to displace it downwards into the pelvic cavity, but this is resisted partly by the powerful posterior sacro-iliac ligaments, which suspend the bone, and partly by the strong hold which the sacrum has upon the ilium, in virtue of the irregularities of the opposed surfaces. Under the influence

of the superincumbent weight there is a tendency on the part of the sacrum to rotate round an axis passing transversely through the sacro-iliac joints. This tendency, however, is checked by the great and small sacro-sciatic ligaments. The ilio-lumbar ligaments prevent displacement of the fifth lumbar vertebra over the base of the sacrum.

Symphysis Pubis.—This belongs to the class **amphiarthrosis.** The articular surfaces are the symphysial aspects of the pubic bones. The ligaments are anterior, posterior, superior, inferior, and interpubic disc. The **anterior pubic ligament** is strong, and is composed of superficial and deep fibres. The superficial fibres are arranged in an obliquely decussating manner, and are chiefly constructed by the aponeurotic fibres of the external oblique and inner heads of the recti abdominis muscles. The deep fibres are disposed transversely. The **posterior** and **superior pubic ligaments** are weak, and consist of scattered fibres. The **inferior** or **subpubic ligament** is a strong, thick band of fibres, which lies at the antero-superior part of the subpubic arch, where it fills up and rounds off the subpubic angle. It is attached superiorly to the lower part of the interpubic disc, and laterally to the adjacent parts of the inner lips of the descending pubic rami. It is about ¼ inch in depth, and is slightly arched, from which latter circumstance it is known as the *ligamentum arcuatum.* The **interpubic disc** lies between the plates of cartilage which cover the bony articular surfaces. It is composed of fibro-cartilage, is thicker in front than behind, and usually contains a fissure at its upper and back part, which may extend for one half, or even the whole length, of the disc as an oblique cleft, parallel to the plane of the bony surfaces. This fissure is brought about by absorption of the tissues in that situation, and it does not appear until about the tenth year of life. It is larger in the female than in the male.

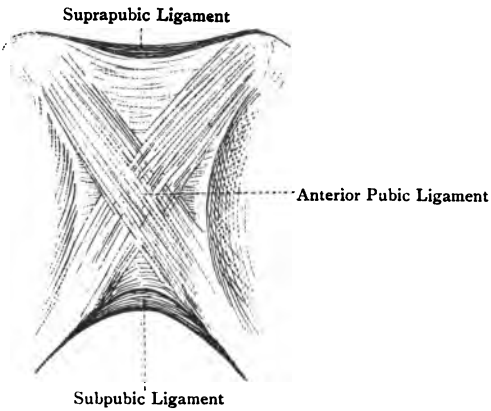


FIG. 365.—THE LIGAMENTS OF THE SYMPHYSIS PUBIS (ANTERIOR ASPECT).

The depth of the symphysis pubis is less in the female than in the male.

Arterial Supply.—Pubic branches of the deep epigastric and obturator, and superior or superficial external pudic arteries.

Nerve-supply.—Probably the hypogastric branch of the ilio-hypogastric, inguinal, and pudic nerves.

Movements.—Very slight separation is allowed at this joint, due to yielding of the connecting structures. This is most apparent during pregnancy and parturition.

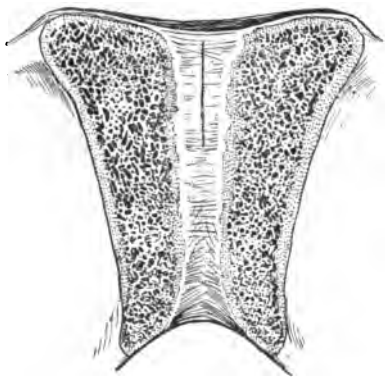


FIG. 366.—VERTICAL SECTION OF THE SYMPHYSIS PUBIS.

Great Sacro-sciatic Foramen.—This foramen is formed by the great sciatic notch, the spine of the ischium, the great sacro-sciatic ligament, and the small sacro-sciatic ligament. For its compartments, and the structures which pass through them, see p. 404.

Small Sacro-sciatic Foramen.—This foramen is formed by the small sciatic notch, the spine of the ischium, the great sacro-sciatic ligament, and the small sacro-sciatic ligament. For the structures which pass through it, see p. 405.

Obturator Membrane and Obturator Canal.

The **obturator membrane,** also called the **thyroid membrane,** is attached to the circumference of the obturator foramen, except superiorly opposite the obturator groove, which it converts into a fibro-osseous canal for the passage of the obturator vessels and nerve. In this situation it is joined posteriorly by the parietal pelvic fascia. Its fibres are arranged in an irregular, decussating manner. Its posterior or pelvic surface is closely covered by the obturator internus muscle. The anterior or femoral surface is in like manner covered by the obturator externus muscle, and at its circumference there is an arterial loop, formed by the external and internal terminal branches of the obturator artery.

The **obturator canal** is a fibro-osseous canal, which is situated above the upper border of the obturator membrane. Its upper boundary, which represents the osseous element, is formed by the obturator groove on the inferior surface of the superior pubic ramus, the direction of the groove being downwards, forwards, and inwards. The lower boundary, which represents the fibrous element, is formed by the junction of the parietal pelvic fascia with the upper border of the obturator membrane over the upper border of the obturator internus. The canal transmits the obturator vessels and obturator nerve, the nerve being above the artery.

GUIDE TO THE DISSECTION OF THE ABDOMEN.

Male Perineum.

Before the subject is placed in the lithotomy positon the dissectors should practise passing the catheter, which should then be left in the urethra and bladder. The subject having been placed in the lithotomy position, the penis and scrotum are to be tied up to the end of the catheter. The first duty of the dissector is to make himself familiar with the landmarks, boundaries, and arbitrary divisions of the perineum, and he should have before him a ligamentous pelvis. He should also introduce his finger well into the rectum, when he will feel through its upper wall the following structures in order from without inwards: (1) the membranous part of the urethra, with the catheter lying in it; (2) the posterior or rectal surface of the prostate gland, easily recognised by its firmness and resistance; and (3) the external trigone of the bladder, which is destitute of peritoneum. The rectum is then to be lightly stuffed with tow, and the margins of the anal aperture are to be brought together with a few stitches. Before removing the skin the dissector should note the antero-posterior median raphé in the uro-genital division of the perineum, and he should follow this raphé over the posterior and anterior surfaces of the scrotum to the under surface of the penis. He should note the position of the central tendinous point, which is about an inch in front of the anus. He should also observe that the anus is situated posterior to a line connecting the front parts of the ischial tuberosities. A slight hollow on the surface between the anus and the tuber ischii indicates the situation of the ischio-rectal fossa.

To remove the skin the following incisions should be made: a median incision, extending from the root of the scrotum to the tip of the coccyx, and surrounding the anus; a transverse incision, extending outwards from the tip of the coccyx for fully 3 inches; another transverse incision, extending outwards from the central tendinous point for fully 3 inches; and a third transverse incision, extending outwards from the anterior extremity of the median incision (at the root of the scrotum) for a similar distance. The sphincter ani externus is to be first displayed. An effort should be made to show the corrugator cutis ani, but this is not an easy dissection. Between the tip of the coccyx and the anus the dissector will meet with the hemorrhoidal or perineal branch of the fourth sacral nerve, and, in the region of the anus and over the ischio-rectal fossa, will be found twigs of the inferior hemorrhoidal nerve. The lower border of the gluteus maximus is next to be dissected, taking care to preserve the gluteal cutaneous branches of the small sciatic nerve and sciatic artery, and the perforating cutaneous branch of the sacral plexus, the latter making its appearance near the coccyx. The dissectors should conjointly make an effort to show the ano-coccygeal body, which lies in the middle line between the tip of the coccyx and the anal canal.

The fat is to be removed from the ischio-rectal fossa, in doing which its loose character is to be noted, as well as the fact that it fills up the fossa, and also extends into the anterior and posterior diverticula connected with it. In removing the fat the dissector should cut from the anus outwards, taking care to preserve the inferior hemorrhoidal vessels and nerve, which cross the fossa transversely. In removing the fat from the front part of the fossa the superficial perineal artery and the two superficial perineal nerves, external and internal, are to be preserved. The outer wall of the fossa is to be dissected, showing the obturator fascia covering the obturator internus muscle, and containing Alcock's canal. Upon one side Alcock's canal should be opened and its contents displayed, in the following order from below upwards: the perineal division of the pudic nerve, vena comes, internal pudic artery, vena comes, and dorsal nerve of the penis. The position of the artery, its distance from the surface, and its relation to the tuber ischii are to be noted. An opening is also to be made in the obturator fascia to

show the fibres of the obturator internus muscle. In dissecting the inner wall of the fossa the anal or ischio-rectal fascia is to be studied, and thereafter removed to show the levator ani muscle descending upon the side of the rectum and anal canal. Posterior to the levator ani is the coccygeus, and emerging between the two will be found the hemorrhoidal or perineal branch of the fourth sacral nerve. Under cover of the lower border of the gluteus maximus there should be shown the inferior border of the great sacro-sciatic ligament. The anterior limit of the fossa is not to be disturbed in the meantime, but the dissector should make himself aware that it is partially limited by the reflection of Colles's fascia round the superficial transverse perineal muscle to join the base of the triangular ligament.

The ischio-rectal fossa having now been displayed, the following points in connection with it are to be noted : its measurements, including its depth; its boundaries, and, in connection with the outer boundary, the position of the internal pudic vessels, and in connection with the inner boundary, the rectum and anal canal ; the loose fat which fills the fossa ; the inferior hemorrhoidal vessels and nerve crossing the fossa from side to side ; and the superficial perineal artery and two superficial perineal nerves in the anterior part of the fossa, passing in a forward direction. It is further to be observed that there are two prolongations or diverticula connected with the fossa, anterior and posterior. The anterior diverticulum is to be found at the front part of the fossa above the junction of Colles's fascia with the base of the triangular ligament. It is of large size, and reaches almost as far forwards as the symphysis pubis, but it will be better understood in the deep dissection of the anterior part of the perineum. The posterior diverticulum will be found between the great sacro-sciatic ligament and the lower border of the gluteus maximus, its direction being outwards and inwards.

The dissector is now to turn his attention to the anterior or uro-genital division of the perineum. The arrangement of the superficial fascia is to receive careful attention. It can easily be shown to be divisible into a subcutaneous fatty layer, having no special name, and a deep membranous layer, known as the fascia of Colles. The subcutaneous fatty layer is traceable backwards over and into the ischio-rectal fossa, outwards to the inner aspect of the thigh, and forwards into the scrotum, where it will be again noticed. The fascia of Colles has an important bearing upon the course taken by urine when extravasated into the anterior part of the perineum. The disposition of this fascia is best studied by inserting the end of a blow-pipe underneath it at its back part, on one side of the middle line. Air having been blown in, the fascia will be seen to be attached externally to each ischio-pubic ramus ; posteriorly it turns round the posterior border of each superficial transverse perineal muscle to join the base of the triangular ligament ; internally (towards the median line) it is continuous with the corresponding fascia of the opposite side ; and anteriorly it passes into the scrotum, where it joins the subcutaneous fatty layer, and forms the tunica dartos. Inflation with air reveals the fact that beneath the fascia there is a space known as the perineal pouch, which is divided posteriorly into two compartments by an incomplete septum. This is demonstrated by the air at first passing forwards on its own side, then crossing the median line, and travelling backwards on the opposite side. Further, the air passes forwards into the scrotal wall beneath the dartos tunic. The attachments of the fascia of Colles clearly explain in what direction extravasated urine can only pass, and from what courses it is debarred.

Beneath Colles's fascia the following structures are to be dissected on each side, namely, the superficial perineal vessels and the three long scrotal nerves. The two superficial perineal nerves will be found entering the perineal pouch at its back part, and the long pudendal nerve of Soemmering will be found appearing through the fascia lata of the thigh about an inch in front of the tuber ischii, after which it passes inwards and forwards, entering the perineal pouch from the outer side. All these structures are to be dissected forwards to the scrotum. The following structures are next to be dissected : the bulbo-cavernosus, covering the bulb in the middle line ; the ischio-cavernosus,

covering the crus penis along the line of the ischio-pubic ramus; and the superficial transverse perineal muscle, in the direction of a line passing inwards and forwards from the tuber ischii to the central tendinous point. This last muscle is often very indistinct, and in its dissection care is to be taken to preserve the transverse perineal artery, which lies close to the muscle.

The dissector should now separate the ischio-cavernosus from the bulbo-cavernosus, and the deep perineal triangle will be thereby exposed. In the area of each triangle a membrane will be seen, which represents the antero-inferior layer of the triangular ligament of the urethra. Through it the fibres of the compressor urethræ muscle may be visible. At this stage the dissector should study the central tendinous point of the perineum, and note the various muscles which are connected with it. The bulbo-cavernosus muscle of one side is now to be carefully removed from the bulb of the urethra, by cutting along the median raphé between the two muscles. The different modes of insertion of the muscle are to be observed, and the bulb of the urethra is to be studied, its relation to the triangular ligament and central tendinous point being noted. The ischio-cavernosus should next be reflected, and attention given to the crus penis.

The dissector is now ready to study the triangular ligament of the urethra. Its antero-inferior layer, also called the subpubic fascia or deep perineal fascia, has been already laid bare in the area of each deep perineal triangle. The several structures piercing it are to be noted, and it should be observed that the base of this layer is joined by the fascia of Colles. This layer having been studied in all its bearings, attention should be directed to the subpubic ligament, which will be found close below the symphysis pubis. The antero-inferior layer of the triangular ligament is now to be carefully removed, and the following structures are to be dissected: the compressor urethræ, the posterior fibres of which are known as the transversus perinæi profundus; the internal pudic vessels and dorsal nerve of the penis, lying close to the ischio-pubic ramus; the following branches of the internal pudic artery, namely, the artery of the bulb or of the corpus spongiosum, lying usually about half an inch from the base of the triangular ligament, the artery of the crus or of the corpus cavernosum, and the dorsal artery of the penis; a plexus of veins lying in the compressor urethræ muscle, and receiving its tributaries from the corresponding corpus cavernosum, and one half of the corpus spongiosum and bulb; and Cowper's glands, two in number, situated one at either side of the middle line, underneath the membranous part of the urethra. The postero-superior or deep layer of the triangular ligament is next to be dissected. It is very ill-defined, and will be found about half an inch above and behind the antero-inferior layer. The structures which pierce it are to be noted, and the anterior diverticulum of the ischio-rectal fossa should now be studied, its floor being formed by the postero-superior layer. The membranous part of the urethra, with the catheter lying in it, is to be examined. The fibres of the postero-superior layer of the triangular ligament should be cut through in order to show the anterior fibres of the levator ani. The various structures which lie between the two layers of the triangular ligament are now to be carefully reviewed.

The dissector is next to direct his attention to the internal pudic artery and pudic nerve, making whatever dissection may now be necessary. The course, relations, and branches of these structures are to be studied. The structures which are divided in the operation of left lateral lithotomy are to be mastered, and, by way of concluding the dissection of the perineum, the dissector should cut transversely downwards at the central tendinous point so as to enable him to turn the anal canal and rectum well backwards. This will expose the rectal surface of the prostate gland.

Female Perineum.

The dissector should practise passing the female catheter before the subject is placed in the lithotomy position. When placed in position, he should make himself familiar with the landmarks of the perineum. Its three divisions are to be noted, and each constituent part of the pudendum

or vulva is to be carefully inspected. The guide already given to the dissection of the ischio-rectal or anal division of the male perineum is equally applicable to that of the female. An effort should be made to show the perineal body, which is peculiar to the female. The guide to it is the central tendinous point, of which it may be regarded as a deep expansion. In connection with the vaginal orifice the following structures are to be dissected: the bulbo-cavernosus or sphincter vaginæ; the bulbi vestibuli, one on either side of the orifice, and the pars intermedia of Kobelt, which is situated in front of the bulbi vestibuli; and the glands of Bartholin, which are also situated on either side of the vaginal orifice, just posterior to the bulbi vestibuli. If these glands should be displayed, an effort should be made to dissect their ducts, each of which is about three-quarters of an inch in length. The muscles requiring special attention are the following: the bulbo-cavernosus or sphincter vaginæ already dissected; and the ischio-cavernosus, or erector clitoridis. The other muscles are practically similar in both sexes. The internal pudic artery takes a similar course in the female to what it does in the male. The pudic nerve is practically the same in both sexes.

Antero-lateral Abdominal Wall.

The first duty of the dissector is to make himself familiar with the surface-markings of the anterior wall of the abdomen. The abdomen is to be inflated with air, by introducing a blow-pipe through the umbilicus. On withdrawing the blow-pipe, the opening is to be secured by a ligature, a circular cut through the skin, around and close to the umbilicus, having been previously made in order to give the string a hold. The skin is to be removed by making the following incisions: a median incision extending from the ensiform process of the sternum to the upper border of the symphysis pubis; an incision along the line of Poupart's ligament from the anterior superior iliac spine to the lower end of the median incision; a transverse incision from the ensiform process to a point as far outwards as the position of the body will allow; and another transverse incision from the anterior superior iliac spine inwards as far as the median line. The skin having been removed, the arrangement of the superficial fascia over the lower part of the anterior abdominal wall is to be studied. The region referred to extends from the level of Poupart's ligament upwards to the level of a line extending horizontally inwards from the anterior superior iliac spine to the linea alba.

A dissection of this region will show that the superficial fascia is divisible into a subcutaneous fatty layer, called Camper's fascia, and a deep membranous and elastic layer, known as Scarpa's fascia. This arrangement of the superficial fascia will at once recall to the dissector a similar arrangement of the superficial fascia of the anterior division of the perineum, the deep layer being there known as the fascia of Colles. A good guide to the separation between Camper's fascia and Scarpa's fascia is the superficial epigastric vessels (especially the vein), Camper's fascia being superficial to them and Scarpa's fascia underneath them. The difference in the naked-eye appearance of the two fasciæ is usually a sufficient indication of the existence of two layers, Camper's fascia being fatty, and Scarpa's fascia membranous. Along the line of the groin the separation is quite distinct, being here effected not only by the superficial epigastric vessels, but also by the inguinal glands (superior or oblique superficial inguinal glands). The dispositions of Camper's fascia and Scarpa's fascia are to be very carefully studied, especially the disposition of Scarpa's fascia, beneath which extravasated urine ultimately comes to lie in cases of rupture of the bulb of the urethra in the perineum. A careful incision is to be made through Camper's fascia transversely inwards from the anterior superior iliac spine. Before dividing it along the linea alba its continuity with the corresponding fascia of the opposite side is to be noted, and, in turning it downwards to the front of the thigh, this should be done in concert with the dissector of the lower limb. A similar transverse incision is next to be made through Scarpa's fascia as deep as the external oblique aponeurosis, and another vertical incision along the linea alba. The fascia

is then to be reflected downwards, partly by using the handle of the scalpel, and partly by using the fingers. Its connection with the external oblique aponeurosis is to be noted ; its attachments along the line of the groin are to be demonstrated ; and the manner in which this fascia, along with the fascia of Camper, is conducted by the spermatic cord into the scrotum to form the tunica dartos (or by the round ligament of the uterus into the labium majus), is to be studied. In the region of the symphysis pubis the suspensory ligament of the penis is to be dissected. The deep fascia is next to be examined. It will be found to be present over the lateral wall of the abdomen, where the external oblique muscle is fleshy, but, on being traced forwards, it will be seen to fade away, and ultimately to disappear, in the region of the aponeurosis of that muscle.

In the course of the foregoing dissection the superficial arteries, with their accompanying veins, are to be displayed, namely, the superior or superficial external pudic, crossing inwards and upwards over the spermatic cord (or round ligament of the uterus) to the suprapubic region ; the superficial epigastric, turning upwards over Poupart's ligament a little to the inner side of the centre ; the superficial circumflex iliac, lying below the outer part of Poupart's ligament ; the anterior cutaneous arteries, emerging through the anterior wall of the sheath of the rectus abdominis, in a somewhat irregular manner, and at variable distances from the linea alba ; and the lateral cutaneous arteries, appearing between the serrations of the external oblique in the mid-axillary line. Simultaneously with the dissection of the foregoing bloodvessels, the following cutaneous nerves should be dissected ; the hypogastric branch of the ilio-hypogastric, piercing the external oblique aponeurosis about an inch above the external abdominal ring ; the anterior cutaneous nerves, emerging through the anterior wall of the sheath of the rectus abdominis in a straggling manner, some appearing near the linea alba, and others a little farther from it ; the lateral cutaneous nerves, which will be found emerging between the serrations of the external oblique in the mid-axillary line, and each of which (with one exception, which immediately follows) divides into an anterior and a posterior branch ; the undivided lateral cutaneous or iliac branch of the anterior primary division of the twelfth thoracic nerve, which should be shown descending over the iliac crest, about an inch behind the anterior superior iliac spine, to the anterior part of the gluteal region ; and the iliac branch of the ilio-hypogastric, descending to the gluteal region over the iliac crest at the junction of the middle and anterior thirds.

The superficial dissection of the penis and the dissection of the scrotum are next to receive attention. The prepuce and frenum præputii are to be examined, and the glans penis is to be studied, attention being paid to the meatus urinarius, corona glandis, and cervix. The median raphé of the scrotum is to be noted, and it may be traceable along the under surface of the penis. A catheter is then to be introduced into the bladder, and the penis is to be made tense by fixing it with string to the end of the instrument. The thin skin of the penis is to be carefully removed, and the reddish-coloured underlying fascia, continuous with the tunica dartos of the scrotum, is to be noted. If not previously dissected, the suspensory ligament is to be displayed, and its bilaminar disposition is to be shown. The fascial investment or sheath of the penis is to be studied, and thereafter the following structures are to be dissected : the dorsal vein, occupying a median position between the corpora cavernosa ; the two dorsal arteries, one on either side of the vein ; the dorsal nerves, each external to the corresponding artery ; and the dorsal penile branches of the superior or superficial external pudic arteries, each lying external to the corresponding main dorsal artery. The dissection of the penis as regards structure is to be postponed until the pelvic cavity is dissected. The scrotum is now to be attended to. Having observed the dark colour and puckered condition of the skin, to the lateral aspect of which twigs of the inguinal nerve are distributed, the dissector is to remove it carefully, and thereafter study the brick-red scrotal fascia, known as the tunica dartos. The relation of the

dartos tunic to Camper's and Scarpa's fasciæ of the anterior abdominal wall, and to the two layers of the superficial fascia of the anterior division of the perineum, is to be carefully noted. The testis is next to be withdrawn from the scrotum, by making forcible traction upon the spermatic cord, and, when this has been done upon both sides, a view will be obtained of the interior of the scrotum. The dissector will notice that there are two scrotal chambers, each lodging a testis, and separated from one another by a partition, known as the septum scroti. The constituent parts of the scrotal wall and scrotal septum are next to receive attention, and the blood-supply and nerve-supply are to be fully reviewed.

The dissector should now replace the testis in the scrotum, and return to the dissection of the antero-lateral wall of the abdomen. The external oblique is to be dissected and studied. In dissecting the posterior border of the muscle its relation to the latissimus dorsi is to be noted. If it is not overlapped by the last-named muscle, the interval between them, called the triangle of Petit, is to be examined. The interdigitations with the latissimus dorsi and serratus magnus are to be shown, and, in connection with the external oblique aponeurosis, the intercolumnar fibres are to be displayed. In the region of the external abdominal ring these fibres are to be shown folding themselves around the spermatic cord in the form of the finger of a glove, thus forming the intercolumnar or external spermatic fascia. The attachment of this fascia along the pubic crest is to be noted, and, partly on this account, and partly by reason of the attachment of the intercolumnar fibres to the pillars of the external abdominal ring, it will be evident that extravasated urine, in passing upwards along the spermatic cord, cannot enter the inguinal canal. The following parts of the external oblique aponeurosis require special attention: Poupart's ligament; Gimbernat's ligament; the triangular fascia or ligament of Colles, which will be found lying within the external abdominal ring behind the spermatic cord and internal pillar; the external abdominal ring; and the linea alba. In connection with the external abdominal ring, its condition is to be carefully studied (1) in its natural state, (2) after partial dissection, a circular cut having been made in the intercolumnar fascia at the mouth of the ring, and (3) after complete dissection, the intercolumnar fibres having been completely removed. The following structures should be observed through the ring, namely, the triangular fascia or ligament of Colles, and the conjoined tendon of the internal oblique and transversalis abdominis. The position of the spermatic cord as it passes through the ring is to be noted.

The removal of the external oblique is to be effected in the following manner: an incision is to be carried inwards through the aponeurosis from the anterior superior iliac spine to the linea alba, and another is to be made vertically downwards in the median line to the symphysis pubis. The triangular flap of the aponeurosis so included, containing the external ring, is to be turned downwards, and left intact, so that it can be replaced when studying the inguinal region in connection with hernia. Beneath this portion of the aponeurosis the dissector is to preserve the hypogastric branch of the ilio-hypogastric nerve as far outwards as about an inch in front of the anterior superior iliac spine. The external oblique is next to be detached from the iliac crest and lower eight ribs, preserving the lateral cutaneous nerves, and the muscle, with the remainder of its aponeurosis, is to be reflected as far forwards as possible. At no point is it possible to reflect it quite up to the linea alba, but it can be reflected more completely below the level of the umbilicus than above it. The reason why the external oblique aponeurosis cannot be separately raised quite up to the linea alba will be seen to be because it blends inseparably with the subjacent anterior lamina of the aponeurosis of the internal oblique. This latter muscle is now to be cleaned, preserving the hypogastric branch of the ilio-hypogastric nerve, and the lateral cutaneous nerves, all of which pierce it. In cleaning the Poupart fibres of the muscle, the origin of the cremaster is to be brought into view. The complex relation of the Poupart fibres to the spermatic cord is to receive attention, and the cremaster is to be dissected. In connection with this muscle the genital

branch of the genito-crural nerve and the cremasteric branch of the deep epigastric artery are to be noted, and the cremasteric fascia is to be studied.

The internal oblique is to be removed in the following manner: make an incision carefully through the muscle just in front of the anterior superior iliac spine, and expose the lateral or intermuscular epigastric branch (so-called ascending branch) of the deep circumflex iliac artery. This is the best guide to the separation between the internal oblique and transversalis abdominis. Now carry an incision inwards through the internal oblique towards the linea alba, and leave the Poupart fibres undisturbed in the meantime. The internal oblique is next to be detached from the iliac crest, from the posterior aponeurosis of the transversalis abdominis, and from the lower three or four costal cartilages, and the muscle, with its aponeurosis, is to be thrown forwards as far only as the outer border of the rectus abdominis. During the reflection of the muscle care must be taken to preserve the following structures, namely, the lower five intercostal nerves; the anterior primary division of the twelfth thoracic nerve (subcostal nerve); the hypogastric branch of the ilio-hypogastric nerve; the inguinal (so-called ilio-inguinal) nerve; the lateral or intermuscular epigastric artery; the abdominal branches of the lumbar arteries; and the lower two intercostal arteries. The transversalis abdominis is next to be cleaned and studied. The lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve are to be followed forwards as far as the outer border of the rectus abdominis, where they disappear by piercing the sheath to get behind the muscle. The posterior aponeurosis of the muscle (which forms the lumbar aponeurosis) cannot be displayed in the present position of the body, but the anterior aponeurosis should be dissected as far as the outer border of the rectus abdominis, where it will be further studied in connection with the sheath of that muscle.

The dissector should now direct his attention to the Poupart fibres of the internal oblique and transversalis abdominis. He will find that the Poupart fibres of the two muscles are intimately connected together, but a careful dissection will show that, whilst the internal oblique arises from the outer half of Poupart's ligament on its abdominal aspect, the transversalis abdominis arises only from the outer third. The former muscle, then, reaches lower down along Poupart's ligament than the latter. An incision having been made through the transversalis abdominis in a transverse direction inwards from the anterior superior iliac spine, the Poupart fibres of the two muscles are to be detached from the ligament, and, in the course of reflecting them inwards without injuring the fascia transversalis, the dissector should observe their varying relations to the spermatic cord and internal abdominal ring, and also the lower border of each muscle. These fibres of the two muscles will be found to end in the conjoined tendon, and this structure should be followed to its insertion and studied. It will be found that the anterior aponeurosis of the transversalis abdominis contributes more to the conjoined tendon than the aponeurosis of the internal oblique. The relation of the conjoined tendon to Hesselbach's triangle will be presently seen. Meanwhile the dissector is to observe that the tendon lies behind the spermatic cord (or round ligament of the uterus), and that it also lies behind the external abdominal ring, thereby strengthening an otherwise weak part of the abdominal wall. The dissector should look for the reflected tendon of Cooper. If present, it will be found as a thin semilunar expansion, extending outwards from the outer border of the conjoined tendon to the inner and lower part of the internal abdominal ring, where it is attached to the deep crural arch. Its relation to Hesselbach's triangle, as well as to the inguinal canal, will be seen further on in the dissection. At this stage the dissector of the abdomen should associate himself with the dissector of the lower limb in order to make a dissection of the deep crural arch.

The anterior wall of the sheath of the rectus abdominis is now to be opened and reflected by making a vertical incision through it about an inch and a half from the linea alba, and turning one half inwards and the other outwards, preserving at the same time the transmitted nerves. In doing so the close

connection between the anterior wall of the sheath and the tendinous inscriptions of the muscle is to be noted at the following levels, namely, at the umbilicus, opposite the tip of the ensiform process, and about midway between these two points. Occasionally a fourth connection is established a little below the umbilicus. The anterior wall of the sheath having been reflected, the pyramidalis muscle should be dissected. If present, it will be found in front of the lower part of the rectus abdominis. The rectus itself is then to be fully dissected. Its two heads of origin and three slips of insertion are to be shown, and the three (sometimes four) tendinous inscriptions are to be studied. The varying relation of the inner border of the muscle to its fellow along the linea alba is to be observed, and both borders of the muscle are to be freed from their connections. In freeing the outer border, the lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve are to be shown on their way to the back of the muscle (within the sheath). The deep epigastric artery is to be displayed, disappearing beneath the outer border of the muscle at a point about midway between the upper border of the symphysis pubis and the umbilicus. Before further disturbing the muscle, the triangle of Hesselbach is to be studied. It will be found between the lower fourth of the rectus abdominis and the deep epigastric vessels. The relation of the conjoined tendon to the triangle, and the manner in which it divides the triangle into two compartments are to be noted. If the reflected tendon of Cooper should be present, its relation to the triangle is also to be noted.

The rectus abdominis is now to be raised from its sheath, but not yet divided. As this is being done, the lower five intercostal nerves and the anterior primary division of the twelfth thoracic nerve will be seen making their way from behind forwards through the muscle to become anterior cutaneous nerves. At this stage also the superior epigastric artery is to be shown entering the deep surface of the upper part of the muscle from behind the seventh costal cartilage. The continuation of the deep epigastric artery in the substance of the muscle is to be dissected from behind to a point about 2 inches above the umbilicus, and the anastomosis between it and the superior epigastric at that level may be shown. The sheath of the rectus is next to be studied, the muscle itself having been previously divided a little above the umbilicus. The splitting of the internal oblique aponeurosis into two laminæ anterior and posterior, along the outer border of the muscle is to be shown. This, however, will be found to cease at a point a little above the level of the anterior superior iliac spine, below which point the undivided aponeurosis will be found to pass in front of the muscle. The anterior aponeurosis of the transversalis abdominis will be seen to pass behind the rectus for a similar extent to that over which the splitting of the internal oblique aponeurosis takes place ; but, over the lower part of the muscle (below a point a little above the level of the anterior superior iliac spine), it passes in front of it. The deficiency of the sheath posteriorly over its lower fourth is to be noted, and the semilunar fold of Douglas, with the deep epigastric artery passing over it, is to be studied. Sometimes the anterior aponeurosis of the transversalis abdominis will be found to send scattered fibres behind the rectus for a variable distance below the semilunar fold of Douglas. In such cases another curved semilunar fold, known as the band of Henle, is to be looked for from 1 to 2 inches below the semilunar fold of Douglas. The composition of the sheath in front and behind is to be mastered ; the different attachments superiorly of the anterior and posterior walls are to be noted ; the contents of the sheath are to be studied ; and the linea alba should be thoroughly revised. The dissector should next direct attention to that part of the deep epigastric artery which forms the outer boundary of Hesselbach's triangle, showing its relations to the internal abdominal ring and fascia transversalis, and also its two venæ comites. The cremasteric and pubic branches of the artery are to be shown, but the artery itself is not to be followed, at this stage, to its origin from the external iliac. The deep epigastric artery should now be studied throughout its course, its branches should be mastered, and the anastomoses of the vessel should be carefully attended to.

The next stage of the dissection consists in (1) detaching the transversalis abdominis from the iliac crest, (2) cutting through posterior aponeurosis in the region between the iliac crest and the last rib, and (3) dividing the muscle as it escapes from beneath the costal margin. When the muscle has been reflected forwards to the outer border of the rectus, the various nerves on its surface having been divided in front and turned outwards, and the ilio-hypogastric and inguinal nerves being carefully preserved in the region of the iliac crest, a good view will be obtained of the fascia transversalis. Before proceeding to study this fascia, however, it will well repay the dissector to replace for a moment the external oblique, internal oblique, and transversalis abdominis, in order to show the intricate piece of lattice-work which these muscles construct by the varying direction of their fibres, a circumstance which adds materially to the strength of the abdominal wall. The fascia transversalis should be followed upwards beneath the costal margin, where, now very thin, it becomes continuous with the areolar investment of the diaphragm. Towards the lower part of the abdominal wall it becomes better marked. Its disposition along the linea alba and along the iliac crest is to be studied ; its arrangement along the line of Poupart's ligament should be carefully attended to ; the deep crural arch is to be revised in connection with it ; its relation to Hesselbach's triangle is to be noted ; and the internal abdominal ring, with the infundibuliform fascia prolonged from its margins, is to receive the closest attention. To see the ring the spermatic cord (or round ligament of the uterus) should be pulled upon, and a circular incision made through the infundibuliform fascia close to the ring. In performing this dissection, it will be seen that the infundibuliform fascia is prolonged upon the cord as the internal spermatic fascia. If the cord be pulled upon it will be seen to receive a covering from the subperitoneal fat or areolar tissue through the internal ring. The internal abdominal ring in all its bearings is to be fully studied, and the relation of the deep epigastric vessels to it carefully noted. At this stage the deep circumflex iliac artery should be dissected in the first part of its course. It will be found in a canal behind the outer half of Poupart's ligament formed by the meeting of the fascia transversalis and fascia iliaca, but it should not be dissected at this stage beyond the anterior superior iliac spine, in which region it will be found to pierce the fascia transversalis.

The inguinal canal is next to be attended to, and its boundaries and relations studied. The spermatic cord, or round ligament of the uterus, according to the sex, is to be observed traversing it throughout, and the inguinal nerve will be found in the lower two-thirds of the canal, after which it will be seen to emerge through the external abdominal ring external to the spermatic cord. Hesselbach's triangle should be revised at this stage, and the relation of the conjoined tendon to the inguinal canal is to be noted. Further, if the reflected tendon of Cooper should be present, its relation to the canal is to be observed. The spermatic cord is next to be dissected. Lying in front of its upper part for a variable distance may be found a thread-like prolongation of the peritoneum. The various coverings of the cord are to be studied, and the dissector is to note that there are three spermatic fasciæ. By teasing and separation the various constituents of the cord are to be shown. Certain of these will not be easily made out, such as the spermatic plexus of nerves and the lymphatics of the testis, but the vas deferens can be separated without difficulty. The spermatic artery (in the centre of the cord), the pampiniform plexus of veins, and the deferential artery are to be looked for. The round ligament of the uterus (a very variable structure in this part of its course) requires very little dissection, and may be followed into the labium majus. A few fibres, representing the cremaster muscle in the male, should be looked for in front of the round ligament. The fascia transversalis is now to be removed as carefully as possible, and in doing so the dissector should observe that it is connected to the underlying peritoneum by the subperitoneal fat or areolar tissue. In connection with this tissue two points have to be noted, namely, (1) internal to the external iliac vein it forms the septum crurale, closing the crural or femoral ring, which should be studied in conjunction with the

dissector of the lower limb; and (2) at the internal ring it is carried downwards with the spermatic cord.

The parietal peritoneum is now to be examined. It will be readily recognised by its bluish-white colour, and upon it a small nodule is to be looked for just behind the internal abdominal ring, representing the upper end of the original processus vaginalis. Instead of a mere nodule the dissector may find a fibrous thread descending for a variable distance on the spermatic cord, and sometimes containing a canal in the female, known as the canal of Nuck. The disposition of the fascia transversalis and fascia iliaca along the outer half of Poupart's ligament, and in the region of the external iliac vessels at the groin is to be attended to, the deep crural arch being at the same time revised. Gimbernat's ligament may be looked to at this stage, but its complete examination should be postponed till a later period.

The abdominal cavity is now to be opened. This is to be done only partially at first by means of the following incisions: commencing immediately below the umbilicus, an incision is to be made downwards and outwards, on either side, to Poupart's ligament at the junction of its inner two-thirds and outer third. In this manner a triangular portion of the anterior abdominal wall below the umbilicus can be thrown down. The parietal peritoneum lining this portion having been sponged, the following plicæ and fossæ are to be studied: (1) Folds.—(*a*) plica urachi, in the middle line; (*b*) plica hypogastrica; and (*c*) plica epigastrica, which is usually a little external to the plica hypogastrica, though sometimes the two correspond. (2) Fossæ.—These are the internal, middle, and external inguinal fossæ. The relations of the internal and middle fossæ to the two divisions of Hesselbach's triangle are to be noted, as well as the relation of the external fossa to the internal abdominal ring. At this stage the dissector should study the descent of the testis, and the abnormal conditions of the processus vaginalis. A complete revisal of all the structures of the abdominal wall in the region of Poupart's ligament should now be made, and thereafter inguinal hernia is to receive careful attention in the following order: external oblique hernia; internal direct hernia; internal oblique hernia; congenital hernia; and infantile hernia. Having mastered these varieties of hernia, the dissector should now turn his attention to umbilical hernia, or exomphalos. The relation of structures at the pubic crest is next to be mastered, as well as the relation of parts at the pectineal portion of the ilio-pectineal line.

It will be proper to dissect the testis at this stage, if it is in proper condition. If not, it should be delayed until the organ has been sufficiently hardened by immersion in spirit. The testis, along with the lower part of the spermatic cord, is to be removed and laid upon a board, and the parts are to be kept in position by pins. The tunica vaginalis is to be studied, and the dissector should note that the lower fibres of the cremaster spread out in a scattered manner over its upper part. An attempt should be made to inflate it, by making an aperture in it, just large enough to admit the small end of a blow-pipe. If this is successfully done, an instructive view of the membrane will be obtained. The tunica vaginalis is then to be divided by a vertical incision, when its two parts will come readily into view, namely, tunica vaginalis scroti and tunica vaginalis testis. These two parts having been studied, attention is next to be directed to the following structures: (1) the body of the testis, closely invested by the dense tunica albuginea, which, in turn, is closely covered by the tunica vaginalis testis; (2) the epididymis, which will be seen lying along the posterior border and adjacent portion of the external surface of the testis; and (3) the digital fossa, which is a recess formed by the tunica vaginalis testis between the testis and the epididymis. The epididymis will be seen to be composed of a head or globus major, situated at the upper end; a body, succeeding to the head, long and narrow; and a tail or globus minor, situated at the lower end of the body. Before proceeding further, the dissector should look carefully for the following vestiges of embryonic structures, namely (1) the hydatids of Morgagni, which will usually be seen on the front of the globus major, or on the front of the testis just below the globus major; (2) the organ of Giraldés or para-

didymis, situated on the front of the spermatic cord immediately above the globus major, beneath the visceral layer of the funicular portion of the tunica vaginalis; and (3) the vas aberrans of Haller, situated at the point where the globus minor passes into the vas deferens. The tissue between the globus major and the testis should be carefully unravelled, and an effort made to show the coni vasculosi entering the globus major after leaving the testis. The vas deferens should be shown as it passes off from the globus minor, and the tortuosity which it here presents is to be noted. The tunica albuginea is next to be opened by making a vertical, median, anterior incision. On separating the two halves from the substance of the testis the dissector is to observe the fibrous processes, thereby torn, which pass into the interior of the organ between the lobuli testis. An attempt should now be made to show the lobuli testis by teasing out the glandular tissue, which may bring into view the tubuli seminiferi. A transverse incision should next be made through the testis, in order to show the forward projection of the tunica albuginea from the back part of the testis into the interior for a short distance, known as the corpus Highmorianum, or mediastinum testis.

The abdominal wall above the umbilicus is to be removed by making a vertical incision through it at either side of the middle line, thus preserving meanwhile a median strip. The lateral parts of the wall are then to be divided along each costal margin as far back as the position of the body will allow. Reverting to the median vertical strip, the dissector should study on its posterior surface a median fold of parietal peritoneum, representing a part of the falciform ligament of the liver, which contains the obliterated umbilical vein. The umbilicus and this peritoneal fold are to be preserved.

Without in any way disturbing the contents of the abdominal cavity, the dissector should remove with a sponge any fluid which may have accumulated. He should then make himself acquainted with the various regions into which the cavity is divided, and the lines and planes by which these divisions are effected. He should also study the boundaries of the cavity. The succeeding stages of the dissection being very complicated, it is advisable that the dissector should exercise considerable method in his mode of procedure. His first duty is to take a *superficial* view of the contents of the abdomen in their undisturbed position, and this should be done in the following order: the liver, the stomach, and the great omentum, depending from the great curvature of the stomach. It should be noted that the great omentum descends lower on the *left* side than on the right, and that a few coils of the ileum are visible beyond it on the right side. The cæcum will be partly seen in the right iliac fossa, and the iliac colon is partly visible in the left iliac fossa.

The great omentum is next to be raised and laid over the costal margin, when the coils of the jejunum and ileum will come into view. The transverse colon will also be seen crossing from the right to the left hypochondrium. If the urinary bladder should be distended, a part of it would be seen in the hypogastrium. The foregoing represent the contents which are seen on taking a superficial view. The coils of the jejunum and ileum should now be carried over to the left side, and the ascending colon examined. Superiorly it will lead to the hepatic flexure, and, without disturbing the parts, the right kidney should be felt. The cæcum will now be fully exposed at the lower end of the ascending colon, and the vermiform appendix, and the mode of ending of the ileum in the large intestine, should be carefully examined. The coils of the jejunum and ileum are then to be carried over to the right side, and the descending colon, commencing above at the splenic flexure and terminating below in the iliac colon, is to be examined. The left kidney is to be felt for, and, if the jejunum is followed upwards, the duodeno-jejunal flexure will be exposed.

The dissector should now study (1) the position and connections of the stomach, and (2) the position and connections of the intestinal canal (except the duodenum, pelvic colon, and rectum). In connection with the small intestine the possible presence of Meckel's diverticulum, about 3 feet from the ileo-cæcal valve, is to be borne in mind. In studying the large intestine,

special attention should be paid to the cæcum, including its varieties, and the vermiform appendix. The ascending, transverse, descending, and iliac colon should next be studied in the order named. The position and connections of the spleen are next to be studied, and for this purpose the stomach is to be well drawn out from the left hypochondrium. It is to be remembered that occasionally accessory spleens are met with in the gastro-splenic omentum, or in the great omentum. The dissector is next to turn his attention to the position, connections, ligaments, and component parts of the liver, in so far as they can at present be made out. The gall-bladder is to be included in this examination.

A study of the foregoing structures will have prepared the dissector for the examination of the peritoneum. The description given of this membrane and its various folds should be read, and it should be compared with, and verified from, the dissection. In a great number of bodies, however, verification is rendered impossible by the existence of adhesions, but the dissector should do his best. The continuity between the parietal and visceral peritoneum is to be shown in two ways, namely, in the vertical direction, and in the transverse direction. The continuity can be demonstrated in the vertical direction without much difficulty, and the best starting-point is the portal fissure of the liver. The peritoneum is to be traced in the transverse direction at two levels, namely, above the transverse colon, or at the level of the foramen of Winslow, and below the transverse colon, or at the level of the umbilicus. The former is difficult of accomplishment, but the dissector should try his best. The latter will not cause much trouble. The various folds formed by the peritoneum, namely, omenta, mesenteries, and ligaments, are next to be studied in the following order: (1) the great omentum; (2) the small omentum; (3) the gastro-splenic omentum; (4) the mesentery proper; (5) the appendicular mesentery or meso-appendix; (6) the transverse meso-colon; (7) the pelvic meso-colon (which, however, belongs to the pelvis); (8) the peritoneal ligaments of th · liver; (9) the peritoneal ligament of the stomach, namely, the gastro-phrenic ligament; (10) the peritoneal ligaments of the spleen, namely, the lieno-phrenic and lieno-renal ligaments; and (11) the peritoneal ligament of the splenic flexure of the colon, namely, the phreno-colic or costo-colic ligament (sustentaculum lienis). In connection with the ascending colon, a peritoneal fold, known as the sustentaculum hepatis, may be met with.

The cavity of the peritoneum is next to be studied, attention being given first to the great cavity, and then to the small cavity. The boundaries of the small cavity are to be studied, which will be facilitated by making an incision through the descending layers of the great omentum about an inch below the great curvature of the stomach. The hand should then be introduced through the incision into the small cavity, and, unless there are adhesions, the dissector will be able to insinuate it downwards between the descending and ascending layers of the great omentum until it is arrested where that omentum describes its bend. In this way the bag or sac of the omentum (great) is demonstrated. He should also pass his hand upwards behind the stomach and gastro-hepatic omentum, and he will feel Spigel's lobe of the liver at the upper end of the small cavity. Thereafter the foramen of Winslow should be mastered. It will be found behind the right or free border of the gastro-hepatic omentum. In order to familiarize himself with this opening, the dissector should again pass his hand into the small cavity through the incision already made below the stomach, keeping the thumb outside in the general cavity. If the hand (except the thumb) is now carried upwards behind the stomach and gastro-hepatic omentum, the index finger can easily be pushed through the foramen of Winslow (unless it is blocked by inflammatory products) into the great cavity, where it can be made to meet the thumb. Again, the index finger of one hand should be passed through the foramen into the small cavity, and the thumb of the same hand should be brought down upon the right or free border of the gastro-hepatic omentum. This having been done, the dissector will have two layers of peritoneum between the index finger and thumb, one of which belongs to the small cavity, and the other

to the great cavity. The structures contained between these two layers are to be noted. As the finger lies in the foramen of Winslow the caudate lobe of the liver will be felt above it. It is possible for a hernia to occur through this foramen.

The relation of the duodenum to the peritoneum should next be attended to. Certain peritoneal fossæ are to be studied in the following order: (1) the duodenal and duodeno-jejunal fossæ; (2) the peri-cæcal fossæ, namely, ileo-colic, ileo-cæcal, and retro-cæcal; and (3) the intersigmoid. The study of the peritoneum in the adult having been concluded, the dissector should attend to the condition of the peritoneum in the fœtus.

The dissection of the mesentery proper should now be proceeded with. The great omentum, with the transverse colon, is to be raised and laid over the costal margin, and the jejunum and ileum are to be carried over to the left side. The dissector is to place portions of the mesentery successively upon a platter, and remove the right or upper layer. The trunk of the superior mesenteric artery is to be dissected beyond the point where it escapes from under cover of the pancreas, and the superior mesenteric sympathetic plexus around it is to be noted, as well as the superior mesenteric vein on its right side. About twelve rami intestini tenuis are to be shown arising from the left side of the parent trunk, and these are to be followed out to their primary, secondary, and at least tertiary arches, attention being given at the same time to the accompanying sympathetic plexuses and veins. During this dissection the mesenteric glands are to be shown, and an effort should be made to display the lacteals, which enter the glands as afferent vessels, and emerge from them as efferent vessels.

The right side of the superior mesenteric artery will be found to give off, in order from above downwards, the inferior pancreatico-duodenal, middle colic, right colic, and ileo-colic branches, but they should be followed out from below upwards. The ileo-colic is to be shown dividing into a colic and an ileo-cæcal branch, the latter of which will be found to give off appendicular, anterior cæcal, posterior cæcal, and ileal branches. The right colic and middle colic are to be shown, each dividing into two branches, the latter lying between the two layers of the transverse meso-colon. Throughout this dissection the tributaries of the superior mesenteric vein are to be noted, as well as the offshoots from the superior mesenteric sympathetic plexus. The inferior pancreatico-duodenal artery should not be followed out at this stage.

The jejunum and ileum are now to be carried over to the right side, and the left branch of the middle colic artery is to be followed to its termination. This will guide the dissector to the descending branch of the left colic artery, and, as he follows this down, he will readily expose the trunk of the inferior mesenteric artery, arising from the aorta about 1½ inches above the bifurcation. In doing so, he is to note that the artery is behind the parietal peritoneum. It will be found to give off a left colic branch, one, two, or three sigmoid branches, and a superior hemorrhoidal branch. The inferior mesenteric sympathetic plexus and ganglion, and the offshoots from the plexus should be noted. The left colic and superior sigmoid arteries are to be followed to their distribution, and the superior hemorrhoidal is to be shown crossing the left common iliac vessels on its way to the pelvis, where it disappears between the two layers of the pelvic meso-colon. The superior hemorrhoidal, sigmoid, and left colic veins will be found to form the inferior mesenteric vein, which is to be followed upwards on the left psoas magnus as high as the pancreas, care being taken to show that it crosses the left spermatic artery and left renal vein.

The intestines are now to be removed in the following manner: a double ligature is to be placed upon the jejunum at its commencement, and another double ligature at the point where the iliac colon passes into the pelvic colon. The gut is then to be divided between each of these double ligatures, and the jejunum and ileum are to be separated from the mesentery proper by dividing the latter with a knife, or clipping it with scissors. When this has been done, the large intestine should be forcibly drawn out from its deep position, any adhesions which it has formed being severed with a knife. The parts of intestine left behind are (1) the duodenum, and (2) the pelvic colon and rectum.

The portion of gut removed is to be cleansed by allowing water to flow through it, and small portions are to be separated, inflated, and dried for future inspection. These portions are to be taken from the following regions : (1) the upper and lower ends of the jejunum ; (2) the upper end, and near the lower end, of the ileum ; and (3) two pieces from the ascending colon. One of these pieces, from the small intestine, is to be dissected in the inflated and moist condition, in order to show the longitudinal and circular muscular fibres. One of the pieces from the ascending colon, when inflated, should also be dissected in the moist condition.

The sacculated appearance and the three muscular tæniæ having been noted, the peritoneum is to be carefully removed, and the arrangement of the muscular fibres studied. Thereafter the three tæniæ are to be divided, and the elongation which then takes place in the wall of the gut is to be observed.

The small intestine is to be opened along the mesenteric border by means of a pair of scissors, one of the points of which has been guarded with a piece of cork. The gut is then to be spread out upon a board, and the characters of the mucous membrane are to be studied. A small portion should be examined under water with the aid of an ordinary lens, which will make clear the villi. With the exception of the cæcum and the first 2 inches of the ascending colon, the large intestine is to be treated in a similar manner. The cæcum and 2 inches of the ascending colon, along with the last 2 inches of the ileum, are to be treated in a different manner. The bowel is to be filled with water from the colic end, the ileal end being left free. It will then be seen that, in distension of the cæcum, no water escapes into the ileum, thus demonstrating the action of the ileo-cæcal valve. The exact attachment of the base of the vermiform appendix should be noted, and the meso-appendix should receive attention. The cæcum and colon are then to be laid open along the right wall, or that opposite the ileum, and the ileo-cæcal valve is to be studied. The opening of the vermiform appendix should be examined, and the valve of Gerlach, guarding it, noted. The extent to which the appendix is pervious should also be attended to.

It is advisable that the dissectors should associate themselves with the dissectors of another abdomen, in order that the cæcum and parts of the ascending colon and ileum from one abdomen may be inflated and dried, so as to allow of the ileo-cæcal valve being examined in the dried state.

The intestines having been studied, the dissector is to cut away the remainder of the mesentery proper, leaving only small portions of the superior mesenteric vessels, as well as of the inferior mesenteric vein, for future reference. A blow-pipe having been introduced into the small portion of the jejunum which has been left, the duodenum and stomach are to be moderately inflated, and the stomach is to be turned upwards. When this has been done, the position and connections of the duodenum are to be studied, the musculus suspensorius duodeni is to be shown passing between the duodeno-jejunal flexure and the left crus of the diaphragm, and the peritoneal fossæ in this region are to be revised. The position and connections of the pancreas are next to receive attention, followed by the spleen and the liver.

The blood-supply of the foregoing viscera should be shown by displaying the cœliac axis without injuring the important plexus of nerves which surrounds it. The axis will be found appearing at the superior border of the pancreas, where it breaks up into gastric, splenic, and hepatic branches, which are to be followed out in the order named. The gastric artery will be seen to pass upwards and to the left behind the small cavity of the peritoneum, and it is to be followed out. The splenic artery is recognised by taking a tortuous course to the left along the superior border of the pancreas, and its pancreatic, left gastro-epiploic, vasa brevia, and proper splenic branches are all to be shown. The hepatic artery is next to be dissected as far as the portal fissure of the liver. In displaying the vessel in front of the foramen of Winslow, opportunity is to be taken to show the common bile-duct descending on its right side, and the vena portæ ascending behind the two. The following branches are to be shown arising from the hepatic artery, all of which are to be followed out: (1) pyloric; (2) gastro-duodenal, dividing into superior

pancreatico-duodenal and right gastro-epiploic; and (3) right and left hepatic. The right hepatic branch will be found to give off the cystic artery, which divides into superior and inferior branches. It is at this stage that the inferior pancreatico-duodenal artery is to be studied.

In dissecting the foregoing arteries, the following groups of lymphatic glands are to be noted: (1) the cœliac glands surrounding the cœliac axis; (2) the gastric glands arranged in two sets—superior, along the small curvature of the stomach, and inferior, along the great curvature; (3) the pancreatic glands along the superior border of the pancreas; (4) the splenic glands near the hilum of the spleen; and (5) the hepatic glands within the gastro-hepatic omentum. The veins corresponding to the arteries are to be preserved, if possible, in connection with the portal system.

The vena portæ is to receive careful attention. Its mode of formation behind the neck of the pancreas is to be noted, and its mode of termination at the right extremity of the portal fissure of the liver, where it presents the portal sinus, is to be shown, with the cystic vein joining its right branch. The sources from which the vena portæ receives its blood should be thoroughly mastered. The common bile-duct is next to be studied. Its formation by the union of the hepatic duct with the cystic duct is to be dissected, and the hepatic duct itself is to be shown as formed by the union of two ducts, one issuing from the right, and the other from the left, lobe of the liver. The duct is to be followed down in front of the foramen of Winslow, behind the first part of the duodenum, and between the head of the pancreas and the second part of the duodenum on their posterior aspect, to about as low as the junction of the upper two-thirds and lower third of the second part. Its mode of termination in the interior of the second part will fall to be noted when the duodenum is opened for inspection.

The liver is now to be removed, in doing which the inferior vena cava should be ligatured below it, and then divided. It must also be divided above the liver, close to the diaphragm. The viscus is then to be thoroughly studied in all its aspects, and so also is the gall-bladder, the interior of which is to be examined to display the reticulated mucous membrane. An effort should be made at this stage to display the right and left pneumogastric nerves as they enter the abdomen through the œsophageal opening of the diaphragm. The right nerve may be followed to the posterior surface of the stomach, and the left to the anterior surface. The stomach, duodenum, pancreas, and spleen are then to be removed *en masse*, the œsophagus having been previously tied below the seat of division. These organs are now to be carefully studied. After washing out the stomach and duodenum, they are to be opened and their interior examined. The main pancreatic duct, or duct of Wirsung, is to be shown by dissecting the pancreas from behind, and an effort should be made to find the small pancreatic duct, or duct of Santorini, in the head of the gland. The junction of the duct of Wirsung with the common bile-duct in the duodenal wall is to be displayed, and the common internal opening of the two ducts is to be examined. The spleen is to be studied, and sections of it should be made and washed, with pressure, under a stream of water, in order to remove the pulp, and show the trabecular framework.

Posterior Wall of the Abdomen.

The prevertebral sympathetic plexuses, namely, the epigastric or solar and hypogastric, with their secondary offshoots, are to be carefully dissected. The dissector will find the great splanchnic nerve piercing the crus of the diaphragm, and it will guide him to the semi-lunar ganglion. These ganglia, two in number, lie at either lateral pole of the solar plexus, close to each suprarenal capsule, that of the right side being under cover of the inferior vena cava. The lower part of each ganglion will be found to be semi-detached as the aortico-renal ganglion, which lies over the root of the renal artery, and terminating in this ganglion will be found the small splanchnic nerve, after it has pierced the crus of the diaphragm. The least splanchnic nerve, if present, may pierce the crus, or it may pass behind the ligamentum

arcuatum internum, to terminate in the renal plexus. Passing inwards from each semilunar ganglion a matted leash of nerve-fibres, mixed with minute ganglia, is to be dissected. These fibres meet in front of the aorta, and invest the cœliac axis and root of the superior mesenteric artery, in which latter situation is the superior mesenteric ganglion. The offshoots from the solar plexus to be shown are as follows: inferior phrenic; cœliac, furnishing gastric, splenic, and hepatic; superior mesenteric; capsular; renal; aortic; spermatic (ovarian in the female); and inferior mesenteric. The spermatic plexus will be seen to come from the renal and aortic plexuses, and the aortic plexus is to be shown in two halves, right and left, which communicate freely with each other over the front of the aorta. The inferior mesenteric plexus will be found to arise chiefly from the left half of the aortic plexus, and the inferior mesenteric ganglion is to be looked for in it, near the root of the artery of that name. The various secondary plexuses will be found to accompany the corresponding branches of the abdominal aorta. The two halves of the aortic plexus, reinforced by branches from the ganglia of the lumbar sympathetic chains, are to be followed over the common iliac arteries, after which they will be found to blend, in the angle between these vessels, to form the hypogastric plexus. This latter is to be shown dividing into the right and left pelvic plexuses.

Attention is next to be directed to the kidneys and suprarenal capsules. The adipose tunic of the kidney is to be carefully removed, and the suprarenal capsule preserved on the upper part of the organ. The great vascularity and copious nerve-supply of the suprarenal capsule are to be noted, and only one vein is to be looked for, emerging from each through an anterior hilum, that of the right side opening into the inferior vena cava, and that of the left into the renal vein of that side. The structures at the hilum of the kidney are to be shown, and the relations of the organ carefully studied, the visceral areas on the anterior surface of each being noted. The inferior vena cava is next to be dissected, and its tributaries shown, one of these on the right side being the spermatic, or ovarian, vein, whilst the vein of the left side, in each sex, is a tributary of the left renal. The abdominal aorta and its branches are to be dissected, followed by the common iliac vessels. Along the front of the aorta the median lumbar glands should be looked for, and along each common iliac artery the so-called common iliac glands. By drawing aside the right crus of the diaphragm, the receptaculum chyli will be found on the right of the aorta, in front of the first and second lumbar vertebræ, and, on the right of it, the right azygos vein. The ureter is to be dissected as low as the pelvic brim, and the pelvis at its upper end is to be shown. The renal vessels are to be studied, and the kidney is then to be removed. The organ is to be divided into two halves by a vertical incision carried from the outer to the inner border. This will show the fibrous capsule (which should be stripped off), sinus, calices, Malpighian pyramids, and cortex.

The diaphragm is next to be dissected. Its central tendon, crura, ligamenta arcuata, and openings are to be studied. The iliac fascia is next to be dissected, with its upward prolongation on the psoas magnus, known as the psoas fascia. Its mode of attachment to the vertebral column and pelvic brim are to be noted, and its disposition at the outer border of the psoas magnus above the iliac crest is to be carefully studied. The nerves on the posterior wall are now to be shown. Emerging from beneath the ligamentum arcuatum externum, and passing along the lower border of the twelfth rib, will be found the anterior primary division of the twelfth thoracic nerve (subcostal nerve), and with it the subcostal vessels. The genito-crural nerve pierces the psoas magnus close to its inner border, singly or in two branches, genital and crural, and these are to be followed, the former to the cremasteric muscular covering of the spermatic cord, and the latter to Poupart's ligament, beneath which it escapes on to the front of the thigh, close to the outer side of the external iliac artery. The ilio-hypogastric and inguinal nerves appear at the outer border of the psoas magnus, and cross the quadratus lumborum close together, the inguinal being the lower of the two. The external cutaneous nerve also appears at the outer border of the psoas magnus below

the preceding, and is readily recognised by crossing the iliac fossa to a point beneath the outer end of Poupart's ligament, where it passes out to the thigh. The anterior crural nerve will be found lying deeply in the groove between the psoas magnus and iliacus, and the obturator nerve will be found lying deeply on the inner side of the psoas magnus, on its way to the lateral wall of the pelvis. If an accessory obturator nerve is present, it will usually be found passing deeply along the inner side of the psoas magnus, close to the pelvic brim, and then coursing over the superior pubic ramus, where it passes beneath the pectineus.

The psoas magnus is now to be dissected, and a psoas parvus is to be looked for. The nerves are then to be followed upwards and inwards to their origins, by cutting through the psoas magnus. In this manner the lumbar plexus will be exposed, which should be carefully dissected, the lumbo-sacral cord being shown, at the same time, descending to take part in the sacral plexus. The gangliated cord of the sympathetic is to be displayed in front of the bodies of the lumbar vertebræ, and the length of its rami communicantes, which accompany the lumbar arteries, is to be noted. The lumbar branches of the aorta are now to be dissected as far back as the intervals between the lumbar transverse processes, where the lateral lumbar glands should be looked for. If the lumbar veins have not been previously dissected, this should now be done. In connection with these veins, at either side, the ascending lumbar vein is to be shown, that of the right side ending as the right azygos vein, and that of the left side ending as the lower left azygos vein. The posterior aponeurosis of the transversalis abdominis and the quadratus lumborum are next to be dissected, and, if that muscle is cut, it will be seen to be encased in a sheath which is formed by the anterior and middle laminæ of the aponeurosis. The iliacus muscle and the external iliac vessels are now to be dissected, and the relation of the vessels to the peritoneum, subperitoneal tissue, and iliac fascia is to be carefully noted, as well as their relation to the genito-crural nerve and constituents of the spermatic cord. The principal branches of the artery, namely, the deep epigastric and deep circumflex iliac, are to be shown, and related to the artery will be found the external iliac glands, three of them being placed just above Poupart's ligament, one on the outer side, another on the inner side, and a third in front of the vessel. The deep circumflex iliac artery is to be followed behind the outer half of Poupart's ligament, and along the iliac crest, and its anastomoses are to be studied. The lacunar region, which lies between Poupart's ligament and the front of the hip-bone, is to be examined, and its two muscular lacunæ, outer and inner, with the vascular lacuna in front of them, are to be shown, with the structures lying in each.

Pelvis.

The pelvis is to be separated by cutting through the disc between the third and fourth lumbar bodies, and then applying the saw. The various muscles connected with the exterior having been trimmed, the bladder is to be partially inflated, and the general position of the viscera and their relations are to be studied, as far as possible, *in situ*. The extent of the pelvic colon is to be noted, and its extensive mesentery, with the superior hemorrhoidal vessels between its two layers, observed.

The reflections of the peritoneum are then to be examined. If a male subject, the relation of the peritoneum to the bladder is to be thoroughly mastered, and the false ligaments, which it forms for the viscus, noted. The recto-vesical pouch of the peritoneum is also to be observed. If a female subject, the relation of the peritoneum to the uterus is to be studied, and the recto-uterine pouch, or pouch of Douglas, is to be carefully examined, which usually contains a few coils of the ileum, and, it may be, a prolapsed ovary. The broad ligament of the uterus, formed by two layers of peritoneum, is to be studied. The position of the Fallopian tube along its upper border, of the ovary with its ligament in a backward extension of it, and of the round ligament of the uterus in a forward extension of it, are to be observed.

The exact position of the ovary should receive special attention, and the corpus fimbriatum of the Fallopian tube, with its ovarian fimbria, is to be noted.

The peritoneum is now to be stripped from the walls of the pelvis to expose the pelvic fascia. On the lateral wall of the cavity the obturator vessels and nerve are to be shown on their way to the obturator canal, through which they pass. The pelvic fascia is then to be carefully examined. This fascia will be seen to line the lateral wall, where it covers the obturator internus, and the posterior wall, where it forms the fascia of the pyriformis. To see it in front, the bladder must be drawn well backwards. The lining portion of the fascia is called the parietal pelvic fascia. To study it more fully the dissector should remove a large part of the os innominatum by means of the following cut: place the saw over the back part of the iliac crest and over the pubic bone, keeping as near as possible to the pelvic brim, but external to it. The bone is now to be sawn downwards in such a manner as to remove a large part of the tuber ischii, but the great and small sciatic notches are to be avoided. The obturator externus muscle is then to be carefully removed from the outer surface of the obturator membrane, and the obturator artery is to be shown in two branches, which form a loop upon the membrane round its circumference. The obturator membrane is then to be removed, which will expose a portion of the obturator internus.

When this part of that muscle is taken away, a good view of the parietal pelvic fascia from the outside will be obtained through the obturator foramen. The thickened portion of the fascia, known as the white line, is to be observed extending from near the lower part of the symphysis pubis to the spine of the ischium. On looking deeply into the pelvic cavity, the bladder having been well displaced to one side, the parietal pelvic fascia, along the white line, will be seen to send inwards its visceral layer, and the portion of the parietal fascia below the white line will be seen, from the perineal point of view, to line the outer wall of the ischio-rectal fossa, where it contains Alcock's canal. From the under aspect of the white line the levator ani muscle arises, and immediately below this the parietal pelvic fascia gives off the anal fascia, which covers the perineal surface of the levator ani. The dissector will now understand what structures separate the pelvic cavity, on either side of the bladder, from the ischio-rectal fossa, this partition being formed, from above downwards, by the visceral pelvic fascia, the levator ani, and the anal fascia.

At the upper part of the obturator foramen the parietal pelvic fascia should be shown, on the side not yet dissected, to join the upper border of the obturator membrane over the obturator internus muscle, thus converting the obturator groove on the under surface of the superior pubic ramus into a fibro-osseous tunnel, called the obturator canal. Through this canal the obturator vessels and nerve will be seen to pass, and it will be evident that the obturator artery escapes from the pelvic cavity without piercing the parietal pelvic fascia. As the parietal fascia is attached along the ischio-pubic ramus, at either side, it is continued inwards until it meets with the urethra. This portion of it, with its fellow, forms the postero-superior layer of the triangular ligament. From the urethra the fascia is continued backwards over the anterior border of the levator ani to the prostate gland, where it becomes continuous with the visceral layer of the fascia, which ensheathes that gland.

The visceral layer of the fascia is now to be followed inwards to the bladder, rectum, and prostate gland. Opposite the vesicula seminalis it divides into an upper or vesical, a middle or recto-vesical, and a lower or rectal layer, the vesical layer forming the lateral true ligament of the viscus. Opposite the prostate the visceral fascia divides into prostatic, recto-prostatic, and rectal layers. In the female the visceral fascia divides into four layers, namely, vesical, vesico-vaginal, recto-vaginal, and rectal. The bladder being pulled well backwards, two stout bands of the visceral pelvic fascia will be seen to extend from the lower part of the body of each pubic bone over the anterior surface of the prostate gland to the bladder. These constitute the anterior true ligaments of the bladder, and each will be found to contain some of its external longitudinal muscular fibres. Between these two ligaments a well-

marked depression, occupied by fat, is to be shown. To facilitate this dissection, the pelvic brim may be removed on one side.

The prostate gland is now to be exposed, and the anterior fibres of the levator ani shown on its side. Within its fascial sheath will be found the prostatic venous plexus, which receives the dorsal vein of the penis in two divisions. If the subject is a female, a portion of the vagina is to be shown. The ureter, vas deferens, and obliterated hypogastric artery are to be displayed, and their relations noted. The ureter will be found on the lateral wall of the pelvis in front of the internal iliac artery, and, as it curves inwards to the lateral angle of the bladder, it will be seen to be crossed by the vas deferens. In the female, before reaching the bladder, it should be shown to lie on the side of the extravaginal portion of the cervix uteri, and for a short distance on the lateral wall of the vagina at its upper part. The obliterated hypogastric artery will be found passing forwards from the anterior division of the internal iliac artery over the lateral wall of the pelvis towards the apex of the bladder. Thereafter the internal iliac artery and its branches are to be dissected, as follows: from the anterior division, the pervious portion of the obliterated hypogastric, giving off two or three superior vesical arteries; inferior vesical, usually giving off middle hemorrhoidal; obturator; internal pudic; and sciatic; and, from the posterior division, the ilio-lumbar; two or three lateral sacral; and gluteal. The special branches in the female are the uterine and vaginal arteries. The arteries are accompanied by offshoots from the pelvic sympathetic plexus.

In dissecting the branches of the artery, care is to be taken of the nerves which arise from the sacral plexus. By displacing the viscera, this plexus and its branches are to be dissected, including the lumbo-sacral cord. In dissecting the plexus, the nerves which form the lumbo-sacral cord, the cord itself, and the first two sacral nerves are to be shown, by careful dissection, in two divisions, ventral and dorsal, and the third sacral (nervus bigeminus) is to be shown dividing into an upper and a lower branch. The fourth sacral is a nervus furcalis. The sciatic and pudic bands of the plexus are to be displayed. The branches will be found to arise as follows: superior gluteal, by three roots from the dorsal divisions of the descending branch of the fourth lumbar, the fifth lumbar, and the first sacral; inferior gluteal, by three roots from the dorsal divisions of the fifth lumbar, and first and second sacral; muscular branches to the pyriformis, from the dorsal divisions of the first and second sacral; nerve to the obturator internus and gemellus superior, by three roots from the ventral divisions of the fifth lumbar, and first and second sacral; nerve to quadratus femoris and gemellus inferior, from the ventral divisions of the descending branch of the fourth lumbar, fifth lumbar, and first sacral; visceral branches to the bladder, from the third and part of the fourth sacral; small sciatic, by three roots from the posterior aspect of the first, second, and third sacral; perforating cutaneous, by two roots from the posterior aspect of the second and third sacral; great sciatic, which is the continuation of the upper or sciatic band of the plexus; and pudic, which is the continuation of the lower or pudic band. The sacro-coccygeal plexus, formed by part of the fourth sacral, fifth sacral, and coccygeal nerves, is to be dissected, and the pelvic sympathetic cord is to be displayed with the ganglion impar on the first coccygeal vertebra. The middle and lateral sacral arteries are to be followed out, and an effort should be made to show the coccygeal gland of Luschka near the tip of the coccyx. Branches of the middle sacral artery may help to guide the dissector to it. The pyriformis, levator ani, and coccygeus muscles are to be dissected, and the relation of the latter two to the pelvic floor is to be noted. The obturator internus is also to be studied.

Viscera of the Pelvis.—The position of the rectum, and its relations to the bladder and prostate gland in the male, and uterus and vagina in the female, having been studied as far as possible *in situ*, the viscera are to be removed *en masse* along with the superior hemorrhoidal vessels. The bladder, if empty, should be partially inflated, and the rectum and anal canal slightly distended with tow, as well as the vagina, if the subject is a female. The relations of the

rectum are now to be more fully examined, after which the gut is to be separated from the other structures, and subjected to a special dissection. The superior hemorrhoidal artery is to be followed out in two divisions, laterally disposed. The tow having been removed, and one end securely tied, the gut is to be inflated from the other end, which is then to be ligatured. The arrangement of the longitudinal and circular muscular fibres are to be shown, and the thickening of the latter along the anal canal, which gives rise to the internal sphincter, is to be noted. The gut is now to be laid open from end to end, and its interior examined. The valves of Houston, three in number, are to be looked for as transverse crescentic folds. One will be found on the right side fully 3 inches above the anus, and two on the left side about 1 inch above and below the right valve. The part of the bowel surrounded by the internal sphincter muscle is to be studied as the anal canal. The longitudinal folds seen here, called the columns of Morgagni, are to be examined, and a little above the anus these columns will be seen to be connected by circularly-disposed semilunar folds, known as the anal valves. The entire blood-supply of the rectum should be carefully revised.

The bladder is next to be dissected, showing the ureters at the lateral angles, and the vesiculæ seminales and vasa deferentia at the fundus. The commencement of each common ejaculatory duct is also to be shown, this being formed by the union of a vesicula seminalis and vas deferens. The limited area on the fundus, bounded on either side by these structures, and called the external trigone, is to be studied. The peritoneum having been removed from the upper surface of the bladder, the muscular fibres of the viscus are to be displayed as well as possible. They will be found to be arranged as an external longitudinal, a middle circular, and an internal longitudinal, layer, the last being very indefinite. The fibrous cord, representing the urachus, is to be shown passing from the apex of the bladder. The prostate gland is now to be fully examined, and, if not previously dissected, its recto-vesical capsule and the prostatic venous plexus are to be shown. At the base of the gland the dissector should look for the middle lobe, which is represented by the small part lying between the common ejaculatory ducts and the wall of the bladder, the rest of the organ being disposed as two lateral lobes. The membranous part of the urethra is to be shown succeeding to the apex of the prostate gland. A vesicula seminalis may now be cut into, in order to show the reticulated arrangement of its mucous lining. The bladder is to be opened, and its interior carefully examined. The openings of the ureters and the urethral opening are to be noted, and the smooth internal trigone examined, which lies within ridges connecting these openings. The prostate gland is also to be laid open along its anterior surface, and the whole penis is to be laid open, so as to expose the interior of the corpora cavernosa, and the urethra contained in the corpus spongiosum. In the prostatic urethra the central dilatation and the constriction at either end are to be observed, as well as the following markings: the crest, along the posterior wall; the sinus pocularis, having on the lateral margins of its opening, or just within them, the openings of the common ejaculatory ducts; and the prostatic sinus, on either side of the crest, in which the prostatic ducts open. The spongy urethra is next to be examined, and the dilatation towards its centre, and also in the glans, are to be observed, the latter being called the fossa navicularis. The openings of the glands of Littré and the lacunæ of Morgagni are to be noted. The septum pectiniforme of the corpora cavernosa, and their trabecular tissue, which supports the erectile tissue, are to be observed.

In the female the bladder is to be examined as in the male. The absence of a prostate gland is to be noted, and the urethra is to be laid open, its shortness and distensibility being observed. The vagina is to be opened from end to end by an incision along the lateral wall. Its mucous rugæ are to be examined, as well as the carunculæ myrtiformes at its external orifice, and the lower part of the cervix uteri, which is received into its anterior wall at the upper end. The transverse slit of the os uteri externum is to be studied, along with its anterior and posterior lips. The recesses formed by the vagina around the lower part of the cervix uteri, called the fornices, are to be

explored, and, on introducing the finger into the posterior fornix, the dissector will find that he can palpate the recto-uterine pouch of peritoneum or pouch of Douglas. The uterus is next to be carefully examined, and its relations, peritoneal included, are to be revised. The fundus, body, isthmus, and cervix are to be attended to. On each side of the upper part of the vagina and cervix uteri a collection of fat, called the parametrium, is to be shown. The body of the uterus is now to be laid open from before by a triangular incision, the apex of which is on a level with the isthmus, whence the two limbs diverge upwards and outwards to each lateral angle. The thick, triangular flap of the anterior wall thus formed having been raised, the cavity of the body is to be examined. The smoothness of the mucous lining is to be observed, and the uterine openings of the Fallopian tubes at each lateral angle, as well as the os uteri internum at the isthmus, are to be studied. The cervix is then to be opened along its anterior wall on one side of the middle line, and the arrangement of the mucous membrane, known as the arbor vitæ uterina, is to be noted. The Fallopian tube, with the corpus fimbriatum at its outer end, is to be studied, followed by the round ligament of the uterus. The ovary is next to be fully examined, and the scarred condition of its surface noted. The part of the broad ligament between the ovary and Fallopian tube, called the meso-salpinx, on being held up to the light, may be seen to contain the epoöphoron (paro-varium, or organ of Rosenmüller). In a young subject a few other tubules may be seen nearer the uterus, which are known as the paroöphoron. The ovarian and uterine arteries, if injected, are to be followed to their distribution.

Articulations of the Pelvis.—The sacro-vertebral joint is to be examined, and the sacro-vertebral and ilio-lumbar ligaments dissected. The symphysis pubis is to receive careful attention, and the oblique direction of the joint is to be noted. Its ligaments are to be shown, and the interarticular fibro-cartilage is to be examined. Occasionally an interspace will be found in it towards the upper and back part, in which there may be a little fluid. The movement at this joint is only of a very slight yielding nature, except in the female during parturition. The sacro-iliac joint or synchondrosis is next to be examined. Its anterior ligament is weak. The posterior ligament, however, which is to be studied by partially separating the bones, is of considerable strength, and the part which it takes in supporting weight is to be carefully studied. The great and small sacro-sciatic ligaments are to be studied, and the manner in which they convert the sciatic notches on the posterior border of the hip-bone into foramina is to be noted. The dissector is to observe the cartilaginous facing of the small sciatic notch, and the grooves, with intervening ridges, which it presents, for the columns on the under surface of the tendon of the obturator internus. Finally, the sacro-coccygeal and intercoccygeal joints are to be examined.

THE THORAX

Thoracic Wall.

Muscles—Intercostal Muscles.—These are two in number in each space, external and internal, and they are arranged as thin sheets of obliquely-disposed muscular fibres, with a large admixture of tendinous fibres.

External Intercostal Muscles—*Origin.*—The lower border of the upper rib.

Insertion.—The outer margin of the upper border of the lower rib.

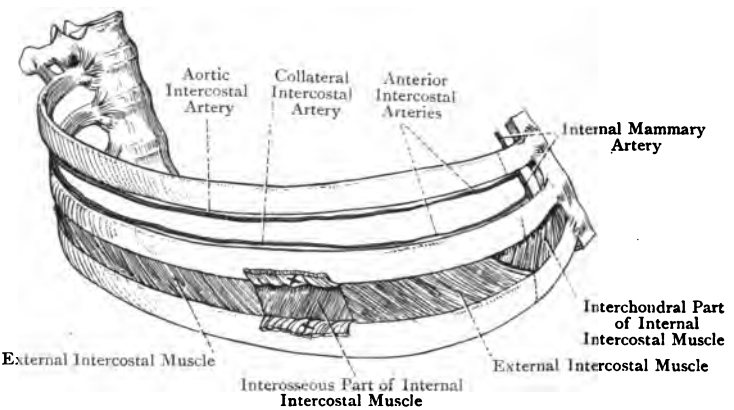


FIG. 367.—DIAGRAM OF THE INTERCOSTAL MUSCLES AND INTERCOSTAL ARTERIES

(A small portion of the external intercostal muscle has been divided and reflected).

Nerve-supply.—The intercostal nerve of the corresponding space.

The fibres of each muscle are directed downwards and forwards, and in this respect coincide with those of the obliquus externus abdominis. The muscles, as a rule, extend as far forwards as the junction of the ribs with their cartilages, but sometimes they stop short of this point, especially in the upper spaces. From the

point where the fibres cease the upper six muscles are continued inwards to the side of the sternum by a thin delicate membrane, called the *anterior intercostal aponeurosis*. This occupies the spaces between the true costal cartilages. Posteriorly the muscles extend as far as the tubercles of the ribs.

Internal Intercostal Muscles—*Origin.*—The upper margin of the subcostal groove of the upper rib.

Insertion.—The inner margin of the upper border of the lower rib.

Nerve-supply.—The intercostal nerve of the corresponding space.

The fibres of each muscle are directed downwards and backwards, and in this respect coincide with those of the obliquus internus abdominis. The upper six muscles extend as far inwards as the side of the sternum, and the lower two are continuous anteriorly with the obliquus internus abdominis. Posteriorly the muscles extend as far back as the angles of the ribs. In this situation each is replaced by a delicate membrane, called the *posterior intercostal aponeurosis*, which lines the adjacent portion of the external intercostal muscle, and blends behind with the anterior or external superior costo-transverse ligament. The internal intercostal muscles are covered internally by the parietal pleura.

Action of the Intercostal Muscles.—This subject has given rise to much discussion and difference of opinion. Three views are entertained. (1) According to Haller, the external and internal intercostal muscles both act as elevators of the ribs, and are therefore muscles of inspiration. Inasmuch as the fibres of the two muscles decussate, they must, according to this view, act on the principle of the parallelogram of forces. The common nerve-supply of the two muscles tends to favour this view. (2) According to Hamberger, the external intercostal muscles are elevators of the ribs, and therefore muscles of inspiration, whilst the internal intercostal muscles are depressors of the ribs, and therefore muscles of expiration. (3) According to Hutchinson, the external intercostal muscles and the *interchondral portions* of the internal intercostal muscles act as elevators of the ribs, and are therefore muscles of inspiration, whilst the *interosseous portions* of the internal intercostal muscles act as depressors of the ribs, and are therefore muscles of expiration.

When a rib is elevated, its lower border is at the same time everted.

For the levatores costarum muscles, see p. 277.

Intercostal Nerves.—These are eleven in number on each side, and are the anterior primary divisions of the upper eleven thoracic spinal nerves. The anterior primary division of the twelfth thoracic spinal nerve is not an intercostal nerve, but lies along the lower border of the twelfth rib, and is known as the subcostal nerve ('last dorsal nerve').

The lower five intercostal nerves ultimately leave the intercostal spaces and pass on to the anterior abdominal wall.

Upper Six Intercostal Nerves.—Each of these nerves, as it enters the back part of an intercostal space, lies between the posterior

intercostal aponeurosis and the parietal pleura. About the level of the angle of the rib it pierces the posterior intercostal aponeurosis, and passes forwards in the subcostal groove of the upper rib, lying between the intercostal muscles. It continues its forward course in this position, in company with the aortic intercostal artery and intercostal vein, the order of these from above downwards being intercostal vein, aortic intercostal artery, and intercostal nerve. The nerve is concealed by the overlapping lower border of the upper rib. Having reached a point about midway between the vertebral column and the side of the sternum, the nerve gives off

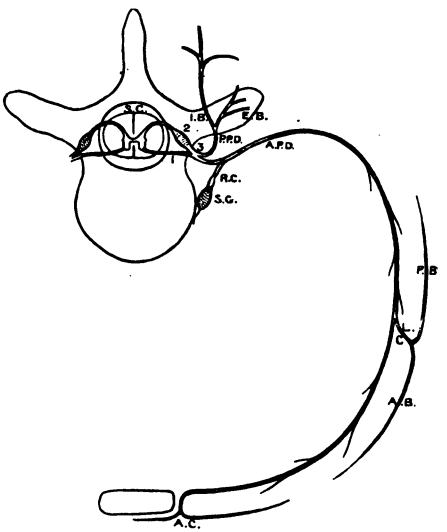


FIG. 368.—SCHEME OF AN INTERCOSTAL NERVE.

S.C. Spinal Cord
1. Anterior Root of Spinal Nerve
2. Posterior Root, with Ganglion
3. Spinal Nerve
A.P.D. Anterior Primary Division (Intercostal Nerve)
S.G. Sympathetic Ganglion
R.C. Rami Communicantes
L.C. Lateral Cutaneous Nerve
A.B. Anterior Branch
P.B. Posterior Branch
A.C. Anterior Cutaneous Nerve
P.P.D. Posterior Primary Division
E.B. External Branch
I.B. Internal Branch

a large branch, called the lateral cutaneous nerve. The intercostal nerve itself, now reduced in size, leaves the intermuscular space hitherto occupied by it, and enters the internal intercostal muscle, in the substance of which it continues its forward course.

Having arrived at the anterior extremity of the osseous rib, the nerve emerges from the internal intercostal muscle and passes inwards on its deep surface, lying at first upon the parietal pleura, and subsequently upon the triangularis sterni muscle, crossing in its course the internal mammary vessels. On reaching the side of the sternum it passes straight forwards, to become an anterior

cutaneous nerve, piercing in succession the following structures : the interchondral portion of the internal intercostal muscle ; the anterior intercostal aponeurosis ; the pectoralis major muscle ; and the deep fascia.

Branches.—These are muscular, lateral cutaneous, and anterior cutaneous.

The *muscular branches* supply the following muscles : the levatores costarum, serratus posticus superior, subcostal muscles, intercostal muscles, and triangularis sterni.

The *lateral cutaneous nerves* arise about midway between the vertebral column and the side of the sternum. They pierce the external intercostal muscles, and make their appearance between the digitations of the serratus magnus (see p. 279). The first intercostal nerve, as a rule, gives off no lateral cutaneous branch, and that of the second is known as the intercosto-humeral nerve.

The *anterior cutaneous nerves* are the terminal branches of the upper six intercostals, that of the first being sometimes absent. For their description, see p. 279.

Intercostal Arteries.—These vessels are arranged in two sets—posterior and anterior.

Posterior Series.—The intercostal arteries of the first two spaces are derived from the *superior intercostal artery* (see p. 952). The intercostal arteries of the lower nine spaces are branches of the descending thoracic aorta, and are called the *aortic intercostal arteries*. Each at first lies between the posterior intercostal aponeurosis and the parietal pleura. About the level of the angle of the rib it pierces the posterior intercostal aponeurosis, and gives off its collateral intercostal branch, which inclines downwards. These two arteries now pass forwards between the two intercostal muscles, the main aortic intercostal lying in the subcostal groove of the upper rib, where it has the intercostal vein above it and the intercostal nerve below it, and the collateral intercostal lying along the upper border of the lower rib. These two vessels, in the case of the upper nine spaces, terminate by anastomosing with the anterior intercostal arteries, which are two in number in each of these spaces, and will be presently described. These anastomoses take place a little in front of the mid-point between the vertebral column and the side of the sternum.

Branches.—These are dorsal, collateral intercostal, and lateral cutaneous.

The *dorsal branch* passes backwards to the muscles and integument of the back, giving off in its course a *spinal branch*, which enters the spinal canal through the intervertebral foramen.

The *collateral intercostal branch*, as stated, arises about the level of the angle of the rib, and inclines downwards to the upper border of the lower rib, along which it passes between the intercostal muscles.

The *lateral cutaneous branch* accompanies the corresponding lateral cutaneous nerve.

The aortic intercostal and collateral intercostal arteries give branches to the intercostal muscles and ribs. Those of the third, fourth, and fifth spaces, at least, furnish branches to the mammary gland and pectoral muscles, which anastomose with the thoracic branches of the acromio-thoracic artery from the first part of the axillary, and with the long thoracic from the second part of that vessel. The first aortic intercostal artery, as it enters the *third* intercostal space, gives off a branch which ascends to the back part of the second intercostal space, and anastomoses with the branch of the superior intercostal artery to that space.

Anterior Series.—The internal mammary artery furnishes two *anterior intercostal arteries* to each of the upper six intercostal spaces, and the musculo-phrenic branch of the internal mammary furnishes two *anterior intercostal arteries* to each of the seventh, eighth, and ninth intercostal spaces. The arteries of the upper six spaces lie at first upon the triangularis sterni muscle, and then upon the parietal pleura, being under cover of the internal intercostal muscle. Afterwards all the anterior intercostal arteries pass between the external and internal intercostal muscles. In each space they anastomose with the aortic intercostal and collateral intercostal arteries, and also with the corresponding intercostal arteries of the upper two spaces.

Branches.—These are distributed to the intercostal muscles, ribs, mammary gland, and pectoral muscles.

The lower two intercostal spaces are not furnished with anterior intercostal arteries. The aortic intercostal arteries of these spaces, after leaving them, enter the abdominal wall, and pass forwards between the internal oblique and transversalis muscles to the rectus abdominis, in which they anastomose with the superior epigastric and deep epigastric arteries.

Intercostal Veins.—These veins accompany the corresponding arteries.

The *chief intercostal vein* passes backwards in the subcostal groove of the upper rib, in company with the aortic intercostal artery, above which it lies. In the region of the angle of the rib it is joined by the *collateral intercostal vein*, which accompanies the corresponding artery. Close to the vertebral column the chief intercostal vein receives a large *dorsal branch*, which returns blood from the muscles and integument of the back, the dorsal spinal venous plexus, and the spinal canal. The mode of termination of the chief intercostal veins differ on each side, and will be described in connection with the dissection of the posterior wall of the thorax.

The *anterior intercostal veins* accompany the anterior intercostal arteries. Those of the upper six intercostal spaces pass to the internal mammary, and those of the succeeding three spaces pass to the musculo-phrenic, veins.

Intercostal Lymphatics.—The lymphatic vessels of the intercostal spaces pass partly to the posterior intercostal glands, which lie at the back parts of the intercostal spaces, and partly to the anterior

intercostal or sternal glands, which lie along the course of the internal mammary artery.

Internal Mammary Artery.—This vessel arises from the lower portion of the first part of the subclavian artery, and it passes downwards, forwards, and inwards behind the inner part of the clavicle and the first costal cartilage. It then descends vertically behind the succeeding costal cartilages as low as the sixth intercostal space, where it terminates by dividing into two branches, namely, the superior epigastric and the musculo-phrenic. The artery lies about ½ inch from the margin of the sternum.

Cervical Relations—*Anterior.*—The clavicular portion of the sterno-cleido-mastoid muscle, and the internal jugular and subclavian veins. The phrenic nerve crosses it superficially from without inwards. *Posterior.*—The dome of the pleura.

Thoracic Relations—*Anterior.*—The pectoralis major ; upper six costal cartilages ; anterior intercostal aponeuroses ; internal intercostal muscles ; and upper six intercostal nerves. *Posterior.*—The pleura above, and subsequently the triangularis sterni muscle. *Lateral.*—The artery has a vena comes on either side of it. The anterior intercostal or sternal glands lie along the course of the vessel.

Branches.—The artery gives off no branches in the neck. In the thoracic part of its course it furnishes the following branches :

Superior phrenic.	Anterior intercostal.
Mediastinal.	Perforating.
Pericardial.	Musculo-phrenic.
Sternal.	Superior epigastric.

The *superior phrenic artery*, long and slender, arises high up, and accompanies the phrenic nerve to the diaphragm, from which circumstance it is known as the *comes nervi phrenici*. It gives twigs to the pericardium and pleura, and in the diaphragm it anastomoses with the inferior phrenic branch of the abdominal aorta and with the musculo-phrenic branch of the internal mammary. The *mediastinal branches* are distributed to the contents of the anterior mediastinum, namely, the remains of the thyroid body, anterior mediastinal glands, and areolar tissue. The *pericardial branches* supply the front part of the pericardium. The *sternal branches* are distributed to the sternum and triangularis sterni muscle. The *anterior intercostal arteries* are two in number to each of the upper six intercostal spaces. For their description, see p. 874. The *perforating branches* are six in number, one arising opposite each of the upper six intercostal spaces. Each vessel pierces the internal intercostal muscle, anterior intercostal aponeurosis, and pectoralis major. Thereafter it gives a few twigs to the front of the sternum, and then turns outwards to supply the pectoral integument. The second, third, fourth, and fifth perforating branches give offsets to the inner portion of the mammary gland.

The *musculo-phrenic artery* is one of the terminal branches of the

internal mammary. It arises from that vessel in the sixth intercostal space, and passes obliquely downwards and outwards behind the seventh, eighth, and ninth costal cartilages. About the level of the tenth rib it perforates the diaphragm and terminates in the lateral wall of the abdomen, where it anastomoses with the lateral epigastric branch (ascending branch) of the deep circumflex iliac artery. It gives off anterior intercostal and muscular branches. The anterior intercostal arteries are two in number to each of the seventh, eighth, and ninth intercostal spaces, in which they are

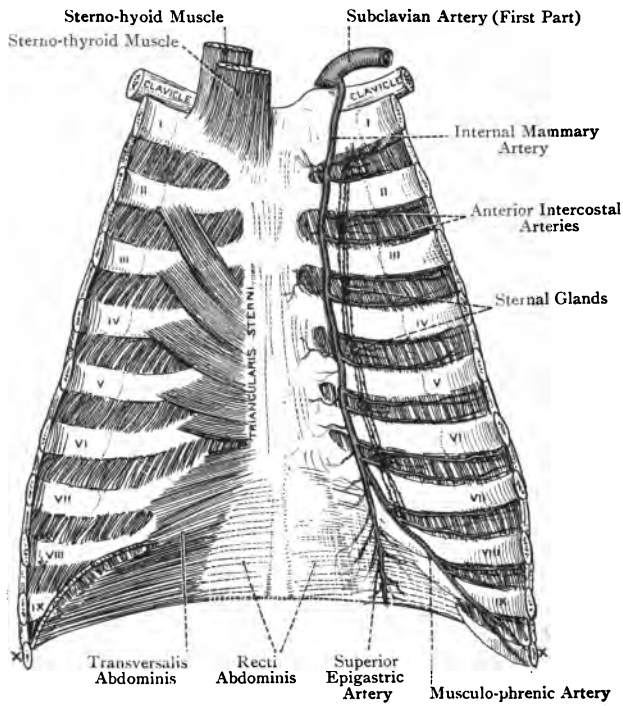


FIG. 369.—DISSECTION OF THE ANTERIOR WALL OF THE THORAX (POSTERIOR VIEW).

disposed in a manner similar to the anterior intercostal branches of the internal mammary. The muscular branches are distributed to the diaphragm and lateral wall of the abdomen. In the diaphragm they anastomose with the inferior phrenic branch of the abdominal aorta and the superior phrenic branch of the internal mammary.

The *superior epigastric artery* is the other terminal branch of the internal mammary, of which it is the continuation. It descends behind the seventh costal cartilage, and passes through the areolar interval between the sternal and costal portions of the diaphragm

In this manner it enters the sheath of the rectus abdominis, lying at first behind the muscle, but afterwards entering it. In the muscle it anastomoses with the deep epigastric artery, which is a branch of the external iliac.

The branches of the superior epigastric artery will be found described on p. 624.

The **internal mammary veins** (*venæ comites*) are two in number, and lie one on each side of the artery. They are formed, respectively, by the union of the venæ comites of the musculo-phrenic and superior epigastric arteries. In their course they receive tributaries corresponding to the branches of the artery. About the level of the first intercostal space the outer vein crosses over the artery and joins the inner vein to form a single vessel, which opens into the corresponding innominate vein. The internal mammary veins are provided with valves at intervals.

Anterior Intercostal or **Sternal Glands.**—These glands are situated along the course of the internal mammary vessels, and are about eight in number. They lie in the intercostal spaces, and they receive their *afferent* lymphatics from the following sources: (1) the inner portion of the mammary gland; (2) the anterior parts of the upper six intercostal spaces; (3) the lymphatics accompanying the superior epigastric artery, which return lymph from the upper part of the anterior wall of the abdomen; and (4) the lymphatics accompanying the musculo-phrenic artery, which return lymph from the anterior parts of the seventh, eighth, and ninth intercostal spaces, and from a portion of the diaphragm. The *efferent* lymphatics of the right glands pass to the right lymphatic duct, and those of the left glands pass to the thoracic duct. Some of the efferent vessels of the lower glands, on each side, become afferent vessels of the anterior mediastinal glands.

Triangularis Sterni—*Origin.*—(1) The deep surface of the ensiform process and body of the sternum, close to the lateral border, and extending as high as the level of the third costal cartilage; and (2) the deep surfaces of the lower two or three true costal cartilages at their sternal ends.

Insertion.—The deep surfaces and lower borders of the costal cartilages from the sixth to the second. The insertion takes place by separate slips, and one or two of the upper slips may be partially attached to the rib itself.

Nerve-supply.—The intercostal nerves of the adjacent spaces.

The lowest fibres of the muscle are horizontal; the succeeding fibres pass obliquely upwards and outwards; and the upper fibres are almost vertical.

Action.—To depress the anterior extremities of the ribs, and so take part in expiration.

The muscle forms a thin musculo-tendinous sheet, which is situated on the deep surfaces of the costal cartilages and side of the sternum, and it is serially continuous with the transversalis abdominis muscle. It supports the internal mammary vessels, sternal

glands, and certain of the intercostal nerves, whilst its deep surface rests upon the parietal pleura.

Thoracic Cavity.

Contents and their General Position.—The thoracic cavity is chiefly occupied by the lungs and heart. The lungs are situated one in each half of the cavity, and each lung is provided with a serous membrane, called the *pleura*. The heart lies obliquely between the lungs, projecting more to the left of the sternum than to the right, and it is enclosed within a fibro-serous sac, called the *pericardium*. Each lung is free to expand except at the *hilum pulmonis*, which is situated on its inner surface. Through this hilum the bronchus, pulmonary artery, and pulmonary veins pass, along with other structures, and the pedicle so formed is called the *root* of the lung. The upper part, or apex, of the lung rises into the root of the neck, where it is covered by the dome of the pleura, that in turn being covered by Sibson's fascia. The lower part, or base, of the lung rests upon the corresponding half of the diaphragm, the heart lying upon the central tendon of that muscle.

The pulmonary artery springs from the base of the right ventricle of the heart, and the aorta from the base of the left ventricle, being at first covered by the pulmonary artery. The left innominate vein courses along the upper aspect of the arch of the aorta in front of the origins of the innominate, left common carotid, and left subclavian arteries, and it unites with the right innominate vein behind the sternal end of the first right costal cartilage to form the superior vena cava. This latter vessel opens into the postero-superior angle of the right auricle of the heart, and, just before piercing the pericardium, it receives the right azygos vein, which arches forwards over the right bronchus. The inferior vena cava, having entered the thorax through the foramen quadratum in the central tendon of the diaphragm, almost immediately opens into the postero-inferior angle of the right auricle of the heart.

The phrenic nerve, on each side, descends in front of the root of the lung, and is intimately related to the pericardium, especially on the left side. The small anterior pulmonary plexus of nerves lies in front of the root of each lung. The pneumogastric nerve, on each side, descends behind the root of the lung, and forms in that part of its course the much larger posterior pulmonary plexus. The following important nerves descend in front of the arch of the aorta : the left phrenic, the left pneumogastric, the upper cervical cardiac branch of the left sympathetic, and the lower cervical cardiac branch of the left pneumogastric. The left superior intercostal vein lies in front of the back part of the aortic arch. The superficial cardiac plexus of nerves lies within the concavity of the arch of the aorta, and the deep cardiac plexus lies behind the arch and in front of the trachea, close to its bifurcation into the two bronchi. The left recurrent laryngeal nerve passes backwards under

the arch, and then ascends behind it. Within the concavity of the aortic arch the trunk of the pulmonary artery breaks up into its right and left divisions, and the ligamentum ductûs arteriosi extends from the root of the left pulmonary artery to the back part of the concavity of the aortic arch, immediately beyond the origin of the left subclavian artery. The gangliated cord of the sympathetic lies very deeply, and descends over the heads of the ribs close behind the parietal pleura, and the two, or three, splanchnic nerves lie obliquely on the sides of the bodies of the lower thoracic vertebræ.

The œsophagus lies in contact with the front of the vertebral column, and the trachea is anterior to it. The descending thoracic aorta lies very deeply, being situated at first on the left side of the vertebral column, but subsequently in front of it. The thoracic duct ascends on its right side, and the right azygos vein ascends on the right side of the thoracic duct, both structures being under cover of the œsophagus. The two left azygos veins, upper and lower, as well as the two transverse azygos veins, upper and lower, are closely related to the vertebral column.

The thoracic cavity contains the following sets of lymphatic glands : the anterior mediastinal, in front of the pericardium ; the superior mediastinal, above the pericardium, along the arch of the aorta and innominate veins ; the posterior mediastinal, behind the pericardium ; the posterior intercostal, in the back parts of the intercostal spaces ; and the bronchial, in the interval between the diverging bronchi, and also at the root of each lung. In early life a portion of the thymus body, which is then of large size, lies behind the upper part of the sternum, whence it extends into the lower part of the neck.

Pleuræ.—The pleuræ are the two serous sacs which invest the lungs, and line the adjacent parietes. Each forms a shut sac, which is quite distinct from its fellow. Like other serous membranes, the pleura consists of two portions—parietal and visceral—which, however, are continuous with one another.

The **parietal pleura** lines the parietes, and is divisible into five portions, namely, costal, diaphragmatic, pericardial, cervical, and mediastinal. The *costal pleura* lines the inner surfaces of the ribs and internal intercostal muscles. The *diaphragmatic pleura* covers the upper surface of one-half of the diaphragm. The *pericardial pleura* is in intimate contact with the pericardium. The *cervical pleura* forms what is known as the **dome,** and rises into the neck for about 1 inch above the clavicle, being a little higher on the right side than on the left, on account of the projection formed by the liver. The *mediastinal pleura* of each side bounds the *mediastinum thoracis.*

The **visceral pleura** closely invests the lung, and is known as the *pulmonary pleura.* It is intimately connected with the lung substance, and extends into the fissure, or fissures, which map out the lung into lobes. Below the root of each lung it forms a fold, called the *ligamentum latum pulmonis,* which descends to the diaphragm, and is connected with the pericardium.

Continuity and Reflections of the Pleura.—(1) *In the transverse direction.*—Commencing at the deep surface of the sternum, the parietal pleura of each side passes backwards to the pericardium, the two being in contact except for a little inferiorly. They form the lateral boundaries of the space which is called the *anterior mediastinum.* When they reach the pericardium the two pleuræ separate, each keeping to its own side of that sac, and so forming the pericardial pleura, which bounds laterally the space known as the *middle mediastinum.* Each pleura in this manner reaches the anterior aspect of the root of the corresponding lung, where it becomes the visceral pleura. This covers the front of the root of the lung, and then invests the entire organ, dipping into its fissure or fissures, as the case may be, and giving a covering to the posterior

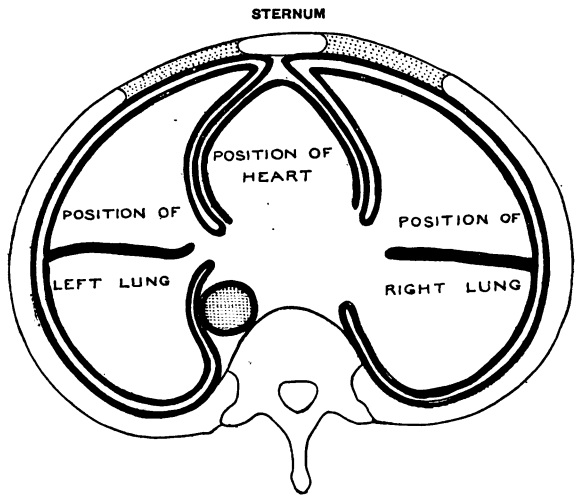


FIG. 370.—DIAGRAM SHOWING THE REFLECTIONS OF THE PLEURÆ (TRANSVERSE SECTION).

aspect of the root. On leaving the back of the root of each lung, the two pleuræ pass backwards, slightly over the pericardium, trachea, and œsophagus, and over the descending thoracic aorta, to the lateral aspects of the bodies of the thoracic vertebræ. These portions form the lateral boundaries of the space which is called the *posterior mediastinum.* From the vertebral column each pleura passes outwards over the gangliated cord of the sympathetic, and then lines the inner surfaces of the ribs, as well as the internal intercostal muscles. In this manner it reaches the deep surface of the sternum.

From the foregoing description it will be evident that the pleura, in passing from the deep surface of the sternum to the vertebral column, meets with, and is reflected over, the lung and its root.

At the level of the manubrium sterni the pleura passes uninterruptedly backwards to the vertebral column. That of the right side passes over the side of the superior vena cava, innominate artery, right innominate vein, and trachea ; whilst that of the left side passes over the side of the left common carotid and left subclavian arteries, œsophagus, and thoracic duct. The two pleuræ, as they pass backwards at this level, form the lateral boundaries of the space which is called the *superior mediastinum.*

Below the level of the root of the lung the antero-posterior reflection of the pleura is complicated by a triangular fold, called the *ligamentum latum pulmonis.* This fold consists of two layers of pleura, in close apposition, which are continuous superiorly with the anterior and posterior pleural investments of the root of the lung. It extends, on the one hand, between the lower border of the root of the lung and the diaphragm, to which latter it is attached, and, on the other hand, between the pericardium and the inner surface of the lung below the level of the root. In the last-named situation its two layers separate, to encase the lung at that level. Its lower border is free and concave.

(2) *In the vertical direction.—Superiorly* the parietal pleura of each side rises, in the form of a dome, into the root of the neck for about 1 inch above the clavicle, where it is covered by *Sibson's fascia.* This fascia is attached, on the one hand, to the internal border of the first rib, and, on the other, to the front of the transverse process of the seventh cervical vertebra. The subclavian artery and innominate vein are intimately related to the dome of the pleura internally and anteriorly, the artery being the higher of the two. *Inferiorly* the parietal pleura of each side is reflected from the thoracic wall on to the upper surface of the corresponding portion of the diaphragm, which it covers where the base of the lung rests upon it. The intervening portion of the diaphragm (central tendon) is covered by the serous portion of the pericardium. Internally the diaphragmatic pleura becomes continuous with the mediastinal pleura.

Lines of Reflection of the Pleuræ—*Sternal Reflection.*—Behind the manubrium sterni the right and left pleuræ are separated from each other by an interspace which represents the *superior mediastinum.* At the level of the junction of the manubrium and body of the sternum they meet each other, and descend behind the body of the bone, in close contact and inclining slightly to the left of the median line. At the level of the lower border of the fourth costal cartilage the *left* pleura parts company with the right, and passes outwards and downwards close to the left border of the sternum, and in intimate relation with the pericardium. There is, however, a small triangular area of that sac which is uncovered by the pleura, and lies in direct relation to the anterior thoracic wall. The left pleura continues its downward course as far as the inner surface of the sixth costal cartilage, lying not far from the left border of the sternum. At this level it again passes outwards and downwards,

to be reflected on to the diaphragm. The *right* pleura pursues an undeviating course downwards behind the sternum as far as the junction of the body and ensiform process. At this level it leaves the bone, and passes obliquely outwards, downwards, and backwards over the inner surface of the seventh costal cartilage, from which it is reflected on to the diaphragm.

Costo-diaphragmatic Reflection.—The level of this reflection may be considered in the first place as it affects certain definite vertical lines. In the left sternal line it takes place at the level of the sixth costal cartilage, and in the right sternal line at the level of the seventh costal cartilage. In the left mammary line it takes place at the level of the eighth costal cartilage, where it joins the osseous part of the rib, and on the right side at a similar level. In the left mid-axillary line it takes place on a level with the lower border of the tenth rib, this being the lowest point to which the pleura descends. In the right mid-axillary line it takes place on a level with the upper border of the tenth rib, or, it may be, the lower border. Posteriorly, in the scapular line (inferior angle of the scapula), on each side, it takes place at the level of the lower border of the twelfth rib. From this point inwards to the vertebral column the line of pleural reflection is a little below the adjacent border of the twelfth rib, and is very nearly midway between the vertebral end of that rib and the first lumbar transverse process.

From the foregoing description it will be evident that the pleura descends lowest in the mid-axillary line, and that posteriorly, close to the vertebral column, it actually descends below the level of the lower border of the twelfth rib. The direction of the line of costo-diaphragmatic reflection, from before backwards, is at first obliquely downwards and outwards, until the level of the tenth rib is reached. Thereafter the line passes backwards and upwards to the vertebral column. The costo-diaphragmatic pleural line is on a distinctly lower level than the margin of the base of the lung, but it is a little above the line of the costal attachment of the diaphragm. The portion of the diaphragm below the line is therefore in direct contact with the thoracic wall and adjacent internal intercostal muscles, without the intervention of the pleura, and the costo-diaphragmatic reflection is connected to these structures by a fascial expansion.

The free surfaces of the parietal and visceral pleuræ are, in health, in close contact. They are polished and moistened by a slight amount of serous fluid, so that they glide smoothly upon each other. In cases of pleurisy, however, certain changes take place. The free surfaces are, in the first place, rendered dry, and thereafter they become roughened at intervals by the deposit of lymph. Under these circumstances the movement of the lung is accompanied by the sound known as pleuritic friction. Adhesions are also frequently formed, and a serous exudation takes place into the pleural sac, which tends to compress the lung injuriously, the condition being known as hydro-thorax. In cases of serous exudation the cavity of the pleura, which is a shut sac, is clearly demonstrable, but in

health no such cavity exists, the parietal and visceral pleuræ being at all times in intimate contact with each other. The attached surfaces of the parietal and visceral pleuræ are roughened by fibrous processes, by means of which they are connected to the parts which they cover.

The costal pleura is the thickest, and can readily be stripped from the inner surfaces of the ribs and internal intercostal muscles. There is a fairly thick layer of subserous areolar tissue on its attached surface. The diaphragmatic and pericardial pleuræ are thinner than the costal pleura, and are more adherent to the subjacent structures. The pulmonary pleura is the thinnest and most adherent. Beneath it there is a layer of subserous areolar tissue, containing much elastic tissue, and this is in continuity with the areolar tissue which pervades the lung.

Differences between the Two Pleural Sacs.—The *right* pleural sac rises higher into the root of the neck, and is shorter and wider, than the *left*. These differences are due partly to the projection formed by the liver on the right side, and partly to the greater inclination of the heart to the left of the sternum than to the right.

Blood-supply.—The *parietal pleura* receives its arteries from (1) the aortic intercostals, and (2) the superior phrenic, anterior intercostal, anterior mediastinal, pericardial, and musculo-phrenic branches of the internal mammary.

The **veins** pursue courses corresponding to the arteries.

Nerve-supply.—The nerves are derived from the sympathetic and phrenic nerves.

Lymphatics.—The pleura and the subserous areolar tissue contain many lymphatic vessels which communicate with the pleural cavity by means of stomata. Those of the parietal pleura pass to the anterior and posterior intercostal glands, whilst those of the visceral pleura are connected with the lymphatics of the lung, which pass to the bronchial glands.

Structure.—The pleura is a typical serous membrane like the serous portion of the pericardium, the peritoneum, and the tunica vaginalis. Such membranes are called *serous* because their free surfaces are moistened by a small quantity of serous fluid. Briefly stated, the pleura consists of a homogeneous, connective-tissue basement membrane, containing elastic tissue, and lined with endothelium. It presents many *stomata*, which communicate with the pleural cavity and with the pleural lymphatic vessels.

Development.—The pleura is developed from the walls of the cœlom, or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Mediastinum Thoracis.—The mediastinum thoracis is formed by the approximation of the two pleural sacs in the region of the median antero-posterior line of the thorax. The interval between the two sacs is called the *mediastinal space*, and its boundaries are as follows : in front, the sternum ; behind, the bodies of the thoracic vertebræ ; and, on either side, the corresponding pleural sac. The mediastinal space contains structures so numerous as to necessitate

its subdivision into four parts—superior, anterior, middle, and posterior.

The **superior mediastinum** is situated above the pericardium, and its **boundaries** are as follows : *in front*, the deep surface of the manubrium sterni, with the origins of the sterno-hyoid and sterno-thyroid muscles ; *behind*, the bodies of the upper four thoracic vertebræ and the lower portions of the longus colli muscles ; *above*, an imaginary plane corresponding to the superior aperture of the thorax ; *below*, an imaginary plane passing from the lower border of the manubrium sterni to the lower border of the body of the fourth thoracic vertebra ; and, *laterally*, the mediastinal pleura of each side as it extends from the deep surface of the manubrium sterni to the vertebral column.

Contents.—These are as follows : (1) the arch of the aorta ; (2) the innominate artery, and the thoracic portions of the left common carotid and left subclavian arteries ; (3) the right and left innominate veins, and the upper half, or extrapericardial portion, of the superior vena cava ; (4) the phrenic, pneumogastric, left recurrent laryngeal, and cardiac nerves ; (5) the trachea, œsophagus, and thoracic duct ; 6) the superior mediastinal glands ; and (7) the remains of the thumus body.

The **anterior mediastinum** is situated behind the body of the sternum, and its **boundaries** are as follows : *in front*, the deep surface of the body of the sternum, and the left triangularis sterni muscle ; *behind*, the pericardium ; and, *laterally*, the mediastinal pleura of each side as it extends from the deep surface of the body of the sternum to the lateral aspects of the pericardium. Its direction is downwards and to the left. At its upper part there is no interspace, because the two pleural sacs come into contact behind the first piece of the body of the sternum. Below this level, however, the left pleural sac diverges from its fellow, so as to leave an interspace.

Contents.—These are the anterior mediastinal glands, some lymphatic vessels, the anterior mediastinal branches of the internal mammary artery, and areolar tissue.

The **middle mediastinum** lies behind the anterior, and below the superior, mediastinum, and is the widest part of the interpleural space.

Contents.—These are as follows : (1) the heart, enclosed in the pericardium ; (2) the ascending aorta ; (3) the trunk of the pulmonary artery ; (4) the lower half, or intrapericardial portion, of the superior vena cava ; (5) the phrenic nerves and the superior phrenic vessels ; (6) the bifurcation of the trachea ; and (7) the roots of the lungs.

The **posterior mediastinum** is situated behind the pericardium, and below the posterior part of the superior mediastinum, with which latter it is continuous. Its **boundaries** are as follows : *in front*, the pericardium, and below this the posterior part of the diaphragm ; *behind*, the bodies of the thoracic vertebræ below the level of the lower border of the body of the fourth ; and *laterally*,

the mediastinal pleura of each side as it extends from the back of the root of the lung to the side of the vertebral column.

Contents.—These are as follows: (1) the descending thoracic aorta; (2) the œsophagus, and the two pneumogastric nerves; (3) the thoracic duct; (4) the right azygos vein; (5) the upper and lower left azygos veins, with the corresponding transverse azygos veins; (6) the great splanchnic nerves, right and left; and (7) the posterior mediastinal glands.

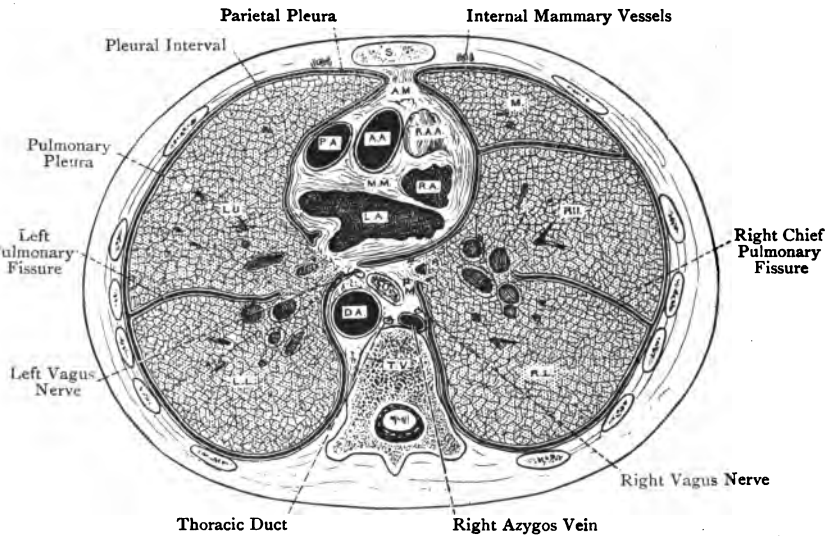


FIG. 371.—TRANSVERSE SECTION OF THE THORAX THROUGH THE SECOND STERNEBRA IN FRONT AND THE BODY OF THE NINTH THORACIC VERTEBRA BEHIND, SHOWING THE REFLECTIONS OF THE PLEURÆ AND THE POSITION OF THE VISCERA.

S. Sternum
A.M. Anterior Mediastinum
A.A. Ascending Aorta
P.A. Pulmonary Artery
R.A.A. Right Auricular Appendix
R.A. Right Auricle
M.M. Middle Mediastinum
L.A. Left Auricle
P.M. Posterior Mediastinum
O. Œsophagus
D.A. Descending Thoracic Aorta
T.V. Thoracic Vertebra
M. Middle Lobe of Right Lung
R.U. Right Upper Lobe
R.L. Right Lower Lobe
L.U. Left Upper Lobe
L.L. Left Lower Lobe

Phrenic Nerve.—This nerve arises chiefly from the anterior primary division of the fourth cervical nerve. It usually receives a small root from the anterior primary division of the third cervical, and, as a rule, an additional root from that of the fifth cervical. Having descended on the superficial surface of the scalenus anticus muscle to the root of the neck, it crosses the internal mammary artery superficially from without inwards. Thereafter it enters the thorax and descends in front of the root of the lung, in close contact with the side of the pericardium, and under cover of the mediastinal

pleura. Having reached the diaphragm, the nerve divides into several branches, which pierce that muscle to be distributed to its abdominal surface. The terminal branches of each nerve are connected, in the diaphragm, with filaments of the corresponding inferior phrenic plexus of the sympathetic, which is an offshoot from the solar plexus. At the place of junction of the two sets of fibres on the right side there is a small ganglion, called the *ganglion diaphragmaticum*. In the thorax the phrenic nerve occupies the superior and middle mediastinal spaces. The *right* phrenic nerve lies, in succession, on the outer side of the right innominate vein and superior vena cava, and then descends in front of the root of the right lung. The *left* phrenic nerve descends in the interval between the left common carotid and left subclavian arteries, where it crosses the left pneumogastric nerve from without inwards. Thereafter it passes behind the left innominate vein, and crosses over the arch of the aorta, after which it descends in front of the root of the left lung. Each nerve is accompanied by the superior phrenic artery, which is a branch of the internal mammary artery.

Branches.—The nerve of each side furnishes twigs to the pericardium and the mediastinal pleura, its principal branches being distributed to the diaphragm.

Differences between the two phrenic nerves—(1) The *right* nerve is shorter than the left, because the right half of the diaphragm, having the bulk of the liver below it, is higher than the left half. (2) The *right* nerve is straighter than the left, because the heart, enclosed in the pericardium, projects less to the right side than to the left. (3) The *right* nerve occupies a deeper position in the upper part of the thorax than the left.

Pericardium.—The pericardium is the fibro-serous sac which loosely surrounds the heart in the middle mediastinum. It is somewhat conical, being wide below, where it is in contact with the diaphragm, and narrow above, where it surrounds the great vessels connected with the base of the heart. On each side it is intimately related to the mediastinal pleura, and is embraced by the inner surfaces of the lungs anterior to their roots. The phrenic nerve, on each side, descends in very close contact with it. In front of it are the body of the sternum and the sternal ends of the corresponding costal cartilages. Its anterior surface is, to a greater or less extent, encroached upon by the adjacent portions of the anterior margins of the lungs and by the two pleuræ. There is, however, a small portion of this surface which is immediately related to the sternum below the level of the lower border of the fourth left costal cartilage at its sternal end. Posteriorly, the pericardium lies in front of the posterior mediastinum, and the œsophagus is here related to it opposite the posterior aspect of the left auricle of the heart.

The pericardium consists of two portions—an external or fibrous, and an internal or serous. The **fibrous portion** is strong and dense. Inferiorly it is attached to the central tendon of the diaphragm, and slightly to its muscular part on the left side.

Superiorly it ensheathes the great vessels connected with the base of the heart, with the single exception of the inferior vena cava. These sheaths are eight in number. One, which is the strongest, invests the whole of the ascending aorta ; two invest the right and left pulmonary arteries ; one surrounds the lower half of the superior vena cava ; and the remaining four invest the pulmonary veins. The inferior vena cava receives no sheath from the fibrous portion, because that vessel opens into the right auricle of the heart almost immediately after it passes through the foramen quadratum in the central tendon of the diaphragm.

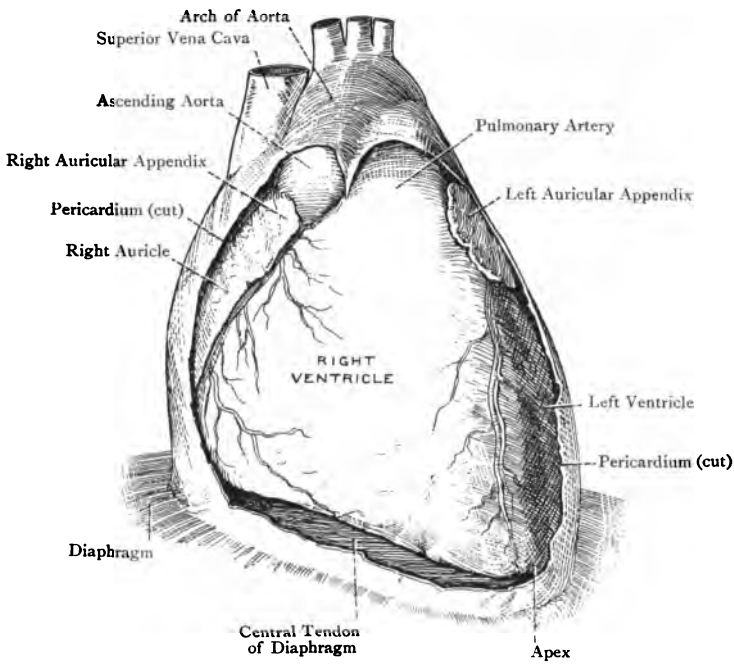


FIG. 372.—THE HEART (ANTERIOR VIEW) AND PERICARDIUM

(The anterior part of the pericardium has been removed).

The fibrous layer is attached to the sternum by two fibrous bands, which are known as the *superior* and *inferior sterno-pericardial ligaments* of Luschka, the former being attached to the deep surface of the manubrium, and the latter to the deep surface of the ensiform process.

The **serous portion** is a typical serous membrane, and consists of two layers, parietal and visceral, which together form a shut sac.

The *parietal portion* lines the inner surface of the fibrous part, to which it is closely adherent, and it also intimately covers the upper surface of the central tendon of the diaphragm.

The *visceral portion*, known as the *epicardium*, closely invests the heart, and also the great vessels at its base more or less completely. The continuity between the parietal and serous portions is established inferiorly along the inferior vena cava. Superiorly the continuity is established along the great vessels at the base of the heart about 1½ inches above it. In this situation the serous portion forms an arterial sheath which encloses within it the ascending aorta and trunk of the pulmonary artery, for, as stated, about 1½ inches, this being the only complete sheath formed by the serous portion. Behind this sheath, with its contents, and in front of the auricular portion of the heart, there is a passage, called the *transverse sinus* of the pericardium, which leads from the right to the left side of the serous sac. The serous portion is also related to the superior vena cava and the pulmonary veins, but it only covers them in front and at the sides.

The serous portion of the pericardium forms a triangular fold, called the **vestigial fold of Marshall,** which is situated between the left pulmonary artery and the upper left pulmonary vein. Its base is directed towards the left, and its surfaces are anterior and posterior. Between its two delicate layers there is a small fibrous cord, which is a vestige of the left duct of Cuvier.

The free surfaces of the parietal and visceral layers of the serous portion are smooth, polished, and lubricated by serous fluid to allow of free movement on the part of the heart. In the course of pericarditis they become at first dry, and then roughened by deposits of lymph, thus giving rise to the pericarditic friction murmur, and, it may be, to adhesions. They may also become separated from each other by effusion into the pericardial sac, thus giving rise to the condition known as hydro-pericardium.

Blood-supply.—The fibrous portion of the pericardium and the parietal layer of the serous portion receive their arteries from (1) the pericardial and superior phrenic branches of the internal mammary, and (2) the descending thoracic aorta. The visceral layer of the serous portion receives arterial twigs from the coronary arteries of the heart.

The **veins** pass to the internal mammary, superior phrenic, and azygos veins.

Nerve-supply.—The phrenic, pneumogastric, and sympathetic nerves.

Lymphatics.—These pass to the anterior, superior, and posterior mediastinal glands.

Structure.—The fibrous portion of the pericardium is composed of fibrous tissue, and is very dense, but not very extensible. The serous portion consists of a homogeneous, connective-tissue basement membrane, containing some elastic fibres, and lined with endothelium. The parietal layer is much thicker than the visceral, and the latter is intimately connected with the cardiac muscular tissue, except along the grooves which are occupied by adipose tissue and bloodvessels.

Development.—The serous portion of the pericardium is developed from the walls of the cœlom, or body-cavity, which is the cleft in the mesoblast separating the splanchnopleure and somatopleure.

Thymus Body (Gland).—This body is present only in the fœtus and young child. It attains its greatest size at the period of birth, and forms a very conspicuous object in the dissection of a child during the first year or two of life. It soon, however, begins to diminish. In its fully-developed condition it is situated partly in the thorax, and partly in the neck. In the former situation it occupies the superior and anterior mediastinal spaces, extending as low as about the level of the fourth costal cartilages, and lying in front of the great bloodvessels and upper part of the pericardium, the upper part of the sternum being in front of it. In the neck it extends as high as the lower part of the thyroid body, being under cover of the sterno-hyoid and sterno-thyroid muscles. In this situation it embraces the front and sides of the trachea, completely concealing it from view, and it encroaches upon the carotid sheath on either side. Its length is about $2\frac{1}{2}$ inches, and its breadth, which is greatest inferiorly, is about $1\frac{1}{2}$ inches. Its colour is pinkish; it is soft in consistence; and its surface shows indications of lobulation. It consists of two asymmetrical lateral lobes, each of which is pyramidal. In some cases the left lobe is the larger, and in other cases the right. These lobes are in close contact, but are still quite distinct. Sometimes a third lobe is present, occupying an intermediate position between the other two.

Blood-supply.—The arteries are chiefly derived from the internal mammary, inferior thyroid, and superior thyroid.

The **veins** open into the right and left innominate and thyroid veins.

Nerve-supply.—The nerves are derived from the sympathetic and pneumogastric.

Structure.—Each lobe has a capsule of fibrous tissue, from which trabeculæ pass into the interior. These trabeculæ map out each lobe into large and small lobules. Each lobule consists of an outer cortical, and an inner medullary, portion. The *cortex* is composed of lymphoid tissue, the lymphoid element predominating over the retiform, and it is surrounded by a capillary network of bloodvessels, which contains many lymph corpuscles. The lymphoid tissue of the cortex is incompletely subdivided into nodules by means of trabeculæ.

The *medulla* is more transparent than the cortex, the retiform element of the lymphoid tissue is more conspicuous, and the lymph corpuscles are less numerous. In addition, the medulla contains small groups of cells, more or less concentrically arranged, which are known as the **concentric corpuscles of Hassall.** According to one view these cells are remains of the diverticula from which the thymus body is developed; but another view is that they are concerned with the formation of bloodvessels and connective tissue.

Development.—The thymus body is developed from the pharyngeal hypoblast. It appears as a tubular diverticulum from the third visceral cleft of each side. These diverticula extend downwards on either side of the trachea towards the heart. Their upper parts lose their connection with the pharyngeal hypoblast, and the lower parts undergo a process of budding, and so give rise to the lateral lobes, which come together in front of the trachea. Subsequently the lobes become pervaded by lymphoid tissue.

Thymus Body in the Adult.—Only the remains of the thymus body are present in the form of a collection of adipose and areolar

tissues, which lies in the superior mediastinum in front of the innominate and left common carotid arteries, above the arch of the aorta. This mass receives a few twigs from the mediastinal branches of the internal mammary artery, and it usually contains a certain amount of the original lymphoid tissue.

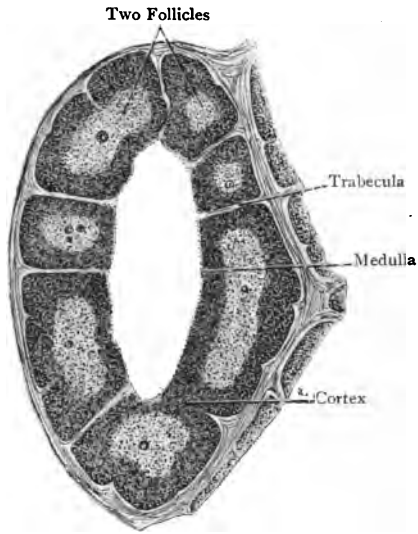


FIG. 373.—TRANSVERSE SECTION OF A LOBULE OF THE THYMUS GLAND OF A KITTEN

(The concentric corpuscles of Hassal are shown in the medulla).

Lungs.—The lungs are two in number—right and left. They are spongy in consistence, float in water, and are readily compressed. When pressed between the fingers crepitation is elicited, this being due to the displacement of air. When the lung is incised, similar crepitation is heard, and a muco-serous fluid, mixed with air, exudes. They possess considerable elasticity, their colour is that of a dark slate, and they are usually mottled, this being due to carbonaceous matter. In early life, however, the colour is rose-pink.

The lungs occupy the greater part of the thoracic cavity. Normally they are at all times in close contact with the thoracic walls, the pleuræ intervening. Unless adhesions have formed during life between the visceral and parietal pleuræ, the surface of each lung is quite free except in two situations, namely, at the root, which occupies a limited area of the inner surface, and at the attachment of the ligamentum latum. Each lung is conical, the base being directed downwards. It presents for consideration an

apex, a base, two surfaces, outer and inner, and two borders, anterior and posterior.

The **apex** is blunt, and rises out of the thoracic cavity into the root of the neck for about 1½ inches. It is here covered by the dome of the pleura, and a little below its highest point it presents a groove on its internal and anterior aspects. In the case of the right lung this groove is produced by the innominate and right subclavian arteries, and, in the case of the left lung, by the subclavian artery of that side. Below this groove there is another

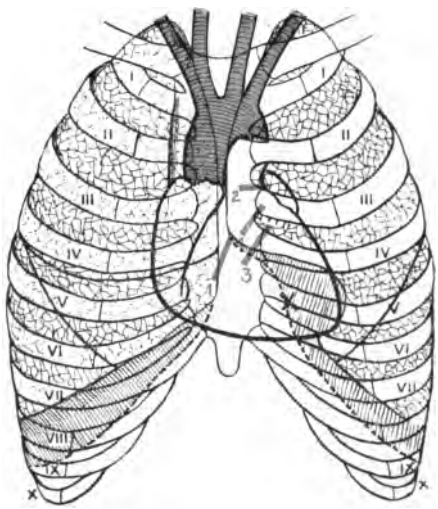


FIG. 374.—DIAGRAM SHOWING THE HEART AND LUNGS IN SITU.

1 Tricuspid Orifice
2 Pulmonary Orifice
3 Mitral Orifice
4 Aortic Orifice
X, Region of Latham's Circle

groove, produced on either side by the innominate and subclavian veins.

The **base** is extensive, semilunar in outline, and concave in adaptation to the upper arched surface of the diaphragm, upon which it rests, with the intervention of the pleura. The base of the right lung is related to the right lobe of the liver, and that of the left lung to the left lobe of the liver, the stomach, and the spleen, the diaphragm intervening in each case. The margin of the base is thin and sharp, and it extends into the costo-diaphragmatic space, reaching lowest behind, but nowhere as low as the line of the costo-diaphragmatic reflection of the pleura.

The **outer surface** is extensive and convex, and in health it is closely applied to the inner surfaces of the ribs and of the internal intercostal muscles.

The **inner surface** is of much more limited extent than the outer.

The greater part of it is concave in adaptation to the heart, enclosed in the pericardium, the concavity being greater in the case of the left lung on account of the projection of the heart to the left side. About the junction of the anterior two-thirds and posterior third this surface presents a vertical fissure, called the *hilum pulmonis*, at which the root of the lung is situated. The inner surface of the *right* lung, behind the hilum, is related to the œsophagus, and the corresponding portion of the inner surface of the left lung presents part of the aortic groove, vertically placed and produced by the descending thoracic aorta. Anterior to the lower part of this groove the left lung is related to the œsophagus, but less

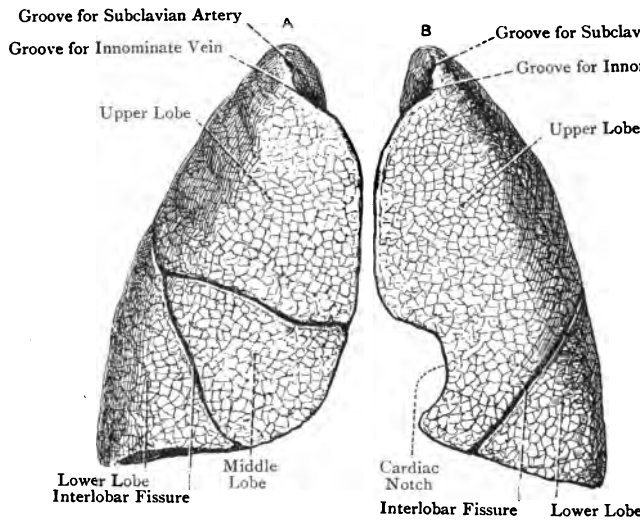


FIG. 375.—THE LUNGS (ANTERIOR VIEW).

A, the Right Lung; B, the Left Lung.

intimately than the right lung. The inner surface of the *right* lung presents the following grooves above the level of the hilum, named in order from below upwards: (1) azygos, for the right azygos vein; (2) caval and innominate, for the superior vena cava and right innominate vein; and (3) arterial, for the innominate artery. The inner surface of the *left* lung presents the following grooves above the level of the hilum: (1) the commencement of the aortic groove, transversely disposed, for the arch of the aorta; (2) the subclavian groove, for the left subclavian artery, leading upwards from the preceding; and (3) an indefinite groove, anterior to the subclavian groove, for the left innominate vein.

The **borders** are anterior and posterior. The **anterior border** is thin and short, and overlaps the pericardium, more so during

inspiration than expiration, but leaving an area of the pericardium uncovered, which is known as the area of precordial dulness. The anterior border of the right lung keeps behind the sternum as low as the sixth right costal cartilage. The corresponding border of the left lung, beyond the lower border of the fourth left costal cartilage, presents a deep V-shaped notch, called the *cardiac notch*, for the reception of the apical portion of the heart, enclosed in the pericardium. The **posterior border** is elongated, thick, and round, and it occupies the pulmonary groove of the thorax, by the side of the thoracic portion of the vertebral column.

Each lung is divided into two **lobes,** upper and lower, by an extensive, oblique, and deep fissure, which penetrates almost to the hilum. So deep is this fissure that, unless adhesions have formed, the lung appears to consist of two halves. The fissure commences on the inner surface, near the posterior border, about 3 inches below the apex. It then turns round the posterior border, and passes obliquely downwards and forwards over the outer surface to the basal margin. In the case of the right lung the fissure joins the basal margin some little distance from the lower end of the anterior border ; but, in the case of the left lung, the fissure joins the basal margin distinctly farther forwards. A good ready guide to this fissure is the lower border of the pectoralis major muscle, as it forms the anterior fold of the axilla.

The **upper lobe** is comparatively small, and includes the apex, about the upper 3 inches of the posterior border, the anterior border, and, in the case of the left lung, practically all that can be auscultated anteriorly. The **lower lobe** is of large size, and lies behind and below the great pulmonary fissure. It includes the base, the posterior border except the upper 3 inches, and practically all that can be auscultated posteriorly.

By means of the great pulmonary fissure each lung, as stated, is divided into two lobes. In the case of the left lung the division proceeds no further. In the case of the right lung, however, there is an additional fissure, which extends from the chief fissure, at the posterior border, horizontally forwards over the outer surface to the anterior border at about the level of the lower margin of the fourth right costal cartilage, which corresponds to the commencement of the cardiac notch on the anterior border of the left lung. This additional fissure cuts off from the upper lobe a triangular or wedge-shaped portion, which is called the **middle lobe.**

Differences between the two lungs—(1) The *right* lung has two fissures and three lobes, whilst the left lung has only one fissure and two lobes. (2) The anterior border of the *right* lung is uninterrupted, whilst that of the left lung presents inferiorly the cardiac notch. (3) The *right* lung is larger and heavier than the left, the weight of the right being about 20 ounces and that of the left about 18 ounces. (4) The *right* lung is shorter than the left, this being due to the fact that the liver causes the right half of the dia-

phragm to rise higher than the left half. (5) The *right* lung is broader than the left, because the heart projects more to the left side than to the right.

Vertical Extent of the Lungs. — In the mammary line the *right* lung descends as low as the sixth rib ; in the mid-axillary line, as low as the eighth rib ; and, in the scapular line (inferior angle of the scapula), as low as the tenth rib. The lower limits of the *left* lung exceed those of the right by about the depth of a rib.

Root of the Lung.—The root is situated at the *hilum pulmonis* on the inner surface. Its chief constituents are as follows : (1) the bronchus or air-tube ; (2) the pulmonary artery, which conveys

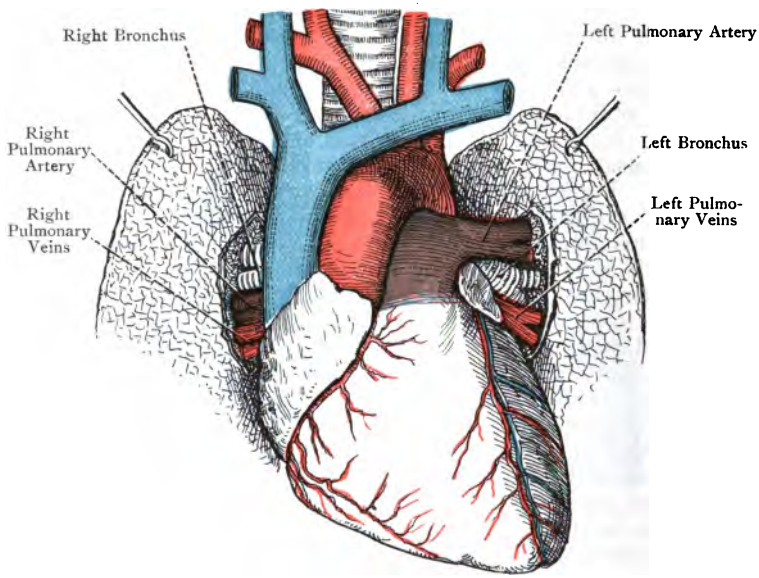


FIG. 376.—THE ROOTS OF THE LUNGS (ANTERIOR VIEW).

venous blood to the lung ; and (3) the two pulmonary veins, which convey the arterial or oxygenated blood from the lung to the left auricle of the heart. In addition to these constituents there are (*a*) the bronchial arteries and veins, (*b*) the pulmonary lymphatic vessels, (*c*) the pulmonary nerves, and (*d*) the bronchial lymphatic glands. All these constituents are connected by areolar tissue, and the entire root is invested by the pleura.

Relations.—The following relations are common to both roots : *in front*, the phrenic nerve, with the superior phrenic artery, and the anterior pulmonary plexus of nerves ; *behind*, the pneumogastric nerve and the posterior pulmonary plexus of nerves ; and, *below*, the ligamentum latum pulmonis.

Special Relations — Right Root — *Anterior.* — The superior vena cava and the upper part of the right auricle of the heart. *Superior.*—The right azygos vein, as it arches forwards over the right bronchus to open into the superior vena cava. *Posterior.*—The right azygos vein. **Left Root** — *Superior.*—The arch of the aorta. *Posterior.*—The descending thoracic aorta.

Relative Position of the Chief Constituents.—The relation *from before backwards* is the same on each side, and is as follows : (1) the upper of the two pulmonary veins ; (2) the pulmonary artery ; and (3) the bronchus. The relation *from above downwards* differs on the two sides. On the *right side* the relation is bronchus, pulmonary artery, and pulmonary veins ; and, on the *left side*, pulmonary artery, bronchus, and pulmonary veins.

The difference in the position of the bronchus on each side is due to the fact that the right bronchus gives off a branch known as the *eparterial* bronchus, which lies above the right pulmonary artery, the larger portion of the right bronchus and the whole of the left bronchus being *hyparterial.*

Structure of the Lungs.—The trachea divides into two bronchi, right and left, the structure of which is similar to that of the trachea. The right bronchus, at about $\frac{3}{4}$ inch from its origin, gives off superiorly a branch, called the *eparterial bronchus*, for the upper lobe of the right lung, and beyond this point, where it is now *hyparterial*, it divides into two branches, one for the middle, and the other for the lower, lobe. The left bronchus is entirely *hyparterial*, and divides into two branches, one for the upper, and the other for the lower, lobe of the left lung. The structure of these primary divisions of the bronchi is similar to that of the bronchi themselves. Within each lung these primary divisions undergo subdivision, to a certain extent dichotomously, but the ramifications are chiefly due to branches being given off laterally, and these never anastomose. The ramifications of the air-tubes within the lungs are called the *bronchial tubes*, and their ultimate subdivisions within the lobules are known as the *bronchioles*. Each bronchiole transmits air to and from a group of infundibula, or ultimate lobules.

Each lobular bronchial tube, after entering a lobule, divides into as many bronchioles as there are groups of infundibula or ultimate lobules. Each bronchiole, on approaching a cluster of, say, two or three infundibula, presents a dilatation, called the *vestibule*, and from this vestibule reception-chambers, known as the *atria*, proceed to the infundibula.

An **infundibulum** or **ultimate lobule** is an irregular, funnel-shaped passage, closed at one end, and having its walls and closed extremity beset with **air-cells** or **pulmonary alveoli,** which also beset, though more sparsely, the walls of the atria.

The bronchial tubes within the lungs are destitute of membranous walls posteriorly, and are cylindrical. This is due to the fact that their irregular plates of cartilage are disposed round the circumference of the wall. The muscular fibres are arranged in complete rings round the tubes, and the elastic tissue forms longitudinal bundles. The mucous membrane is freely provided with racemose mucous glands, and is covered with stratified ciliated columnar epithelium. When the tubes, by division, have attained a diameter of about $\frac{1}{18}$ inch, the cartilaginous plates disappear, and the walls consist of a fibro-elastic membrane and circularly-disposed muscular fibres, with a thin mucous coat, destitute of mucous glands, and covered with simple ciliated columnar epithelium, there being here and there patches of squamous, non-ciliated cells. The walls of the vestibule, atria, and air-cells are very thin and consist of areolar, elastic, and muscular tissues, the elastic element being specially developed at the margins of the orifices of the cells. This elastic

tissue enables the cells to recoil after distension. The interior of the vestibule, atria, and air-cells is lined with a single layer of squamous, non-ciliated

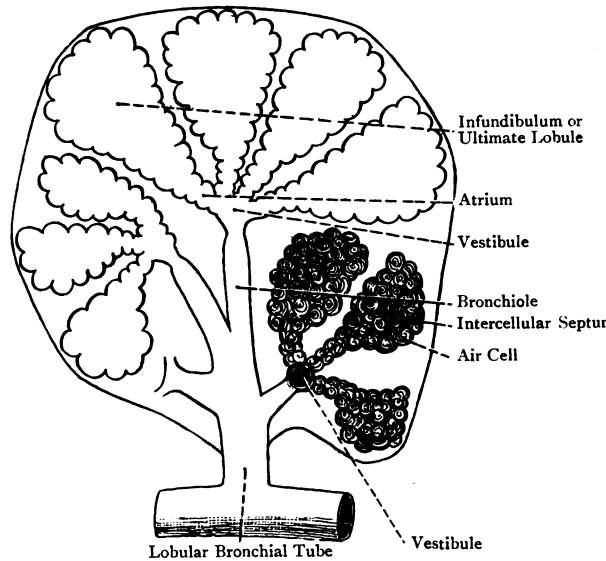


FIG. 377.—SCHEME OF A PULMONARY LOBULE (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

epithelium, which is of extreme delicacy in the air-cells. Upon the outer walls of the cells there are dense networks of capillary bloodvessels, which also pervade the septa between the cells, these septa being formed by infoldings of the contiguous cell-walls. Each septum contains only one capillary layer. The venous blood is thus brought into the most intimate relation with the air, all that separates the two being the very thin walls of the cells and the very delicate walls of the capillary blood-vessels. Moreover, there being only one capillary layer in each intercellular septum, the blood in the septal capillaries is exposed to the air on each side.

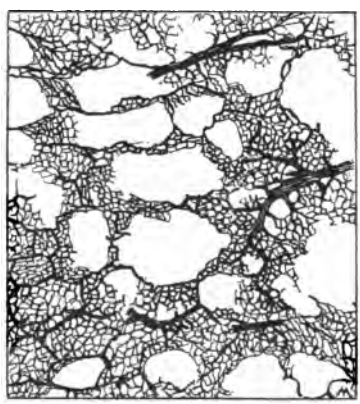


FIG. 378.—SECTION OF LUNG (INJECTED).

Summary of the Structure of the Lung.—The lung consists of an immense number of lobules, irregularly polygonal in outline, and each of these is provided with its own bronchial tube. A lobule is composed of groups of infundibula or ultimate lobules, and the lobular bronchial tube, on entering the lobule, divides into as many bronchioles as there are groups of infundibula. Each bronchiole, on approaching a cluster of infundibula, presents a dilatation, called the vestibule, from which atria lead to the infundibula.

The walls of the infundibula are freely beset with air-cells, which are also present, though more sparsely, on the walls of the atria. Upon the walls of the air-cells are dense networks of capillary bloodvessels, and each intercellular septum contains a single capillary layer.

Bloodvessels of the Lungs.—Two sets of arteries are associated with each lung, namely, pulmonary and bronchial, the former having to do with the respiratory function of the organ, and the latter with the nutrition of its component tissues. The **pulmonary arteries** are two in number, right and left. They result from the bifurcation of the pulmonary trunk, and convey venous blood to the lungs. Each artery ramifies freely within the lung, its branches accompanying the bronchial tubes, but they never anastomose with one another. Ultimately they terminate in dense capillary networks which lie upon the walls of the air-cells, and also in the septa between adjacent cells.

The **pulmonary veins** commence as radicles in the capillary networks already referred to, and they pass to the root of each lung, where they give rise to two pulmonary veins, which proceed to the left auricle of the heart and convey to it arterial or oxygenated blood. The pulmonary veins and their tributaries are destitute of valves. It is to be noted that the pulmonary arteries carry *venous* blood, whilst the pulmonary veins carry *arterial* blood.

The **bronchial arteries** convey arterial blood to the lungs for the nutrition of their component tissues. They will be described in connection with the descending thoracic aorta, with which they are associated.

The **bronchial veins** return their blood chiefly into the right azygos and upper left azygos veins respectively.

Lymphatics.—These are arranged in three sets, namely, superficial, deep or alveolar, and bronchial.

The *superficial lymphatics* are in communication with the copious subpleural lymphatic plexus on the surface of the lung. The *deep* or *alveolar lymphatics* proceed from the walls of the air-cells and from the intercellular septa. The *bronchial lymphatics* originate in the mucous membrane of the bronchial tubes. At the root of each lung the lymphatic vessels enter the bronchial glands.

Nerves.—These are derived from the anterior and posterior pulmonary plexuses, which are formed by the pneumogastric nerves, aided by branches from the sympathetic. The nerves penetrate as far as the air-cells, upon the walls of which they are regarded as terminating in arborizations. The anterior and posterior pulmonary plexuses will be found described on p. 910.

Development of the Respiratory Apparatus.—The earliest indication of the larynx, trachea, bronchial tubes, and lungs is a deep, median, vertical groove, called the *respiratory groove*, which is situated within the horse-shoe elevation known as the *furcula*. It may be here stated that the loop or bend of the furcula gives rise to the epiglottis, its lateral limbs to the aryteno-epiglottidean folds, and their posterior extremities to the arytenoid cartilages. The surroundings of the respiratory groove thus represent the superior aperture of the larynx. The next stage consists in the deepening

of the respiratory groove, so as to form an elongated, vertical, *respiratory diverticulum* of the fore-gut, which communicates freely with it, and consists of hypoblast internally and mesoblast externally. The hypoblast gives origin to the respiratory epithelium, which is therefore continuous with the hypoblast of the fore-gut, and the mesoblast gives origin to the respiratory connective-tissue elements.

The median respiratory diverticulum next becomes separated from the fore-gut, which lies behind it. The separation takes place from below upwards, but in such a manner as to leave a small communication between the two at their upper or cephalic ends, which represents the rudimentary glottis. In this manner two tubes result, namely, posterior or œsophageal and anterior or laryngo-tracheal. The lower end of the respiratory diverticulum divides into two *lung-buds*, right and left, which grow into a collection of mesoblast. These buds represent the right and left bronchi and corresponding lungs. Their hypoblast gives rise to the epithelium, and the mesoblast into which they extend gives rise to the connective-tissue elements.

Each lung-bud subdivides, the right into three processes, and the left into two, thus indicating the three-lobed condition of the right lung and the two-lobed condition of the left. These processes in turn subdivide, and thus represent the ramifications of the bronchial tubes. The terminal parts of the minute ramifications give rise to the infundibula, and the air-cells are formed as diverticula from these infundibula and from the tubes immediately connected with them.

Lungs of the Fœtus.—The lungs prior to birth, having been impervious to air, feel solid, like liver, and they would at once sink if placed in a vessel containing water.

Innominate Veins.—These vessels are two in number, right and left, and each is formed by the junction of the internal jugular and subclavian veins behind the inner end of the clavicle. They both lie in the superior mediastinum.

The **right innominate vein** is about an inch in length, and passes downwards with a slight inclination inwards. At the level of the lower border of the first right costal cartilage, close to the sternum, it unites with the left innominate vein to form the superior vena cava. Externally it is closely related to the right phrenic nerve and right pleura ; its internal relation is the upper part of the innominate artery ; and, behind it, is the right pneumogastric nerve.

The **left innominate vein** is about 3 inches in length, and passes obliquely inwards and downwards from left to right. As stated, it joins its fellow of the right side to form the superior vena cava. In front of it there are the upper part of the manubrium sterni, the origins of the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus body. Behind it are the origins of the innominate, left common carotid, and left subclavian arteries, the left pneumogastric and left phrenic nerves, and two superficial cardiac nerves from the cervical portions of the left pneumogastric and left sympathetic. Below it there is the arch of the aorta.

There are no valves in the innominate veins.

Tributaries. — Each vein receives the following tributaries : (1) the vertebral vein ; (2) the inferior thyroid vein ; (3) the internal mammary vein ; and (4) the first intercostal vein. The last named

vessel, however, sometimes opens into the vertebral vein, and occasionally the right inferior thyroid vein opens into the left innominate vein. The *left* innominate vein receives, as an additional tributary, the left superior intercostal vein.

Development.—The *right* innominate vein is developed from that portion of the right primitive jugular vein which lies between the point where it receives the right subclavian and right internal jugular veins and the point where it is joined by the transverse jugular vein. The greater part (almost the whole) of the *left* innominate vein is developed from the transverse jugular vein.

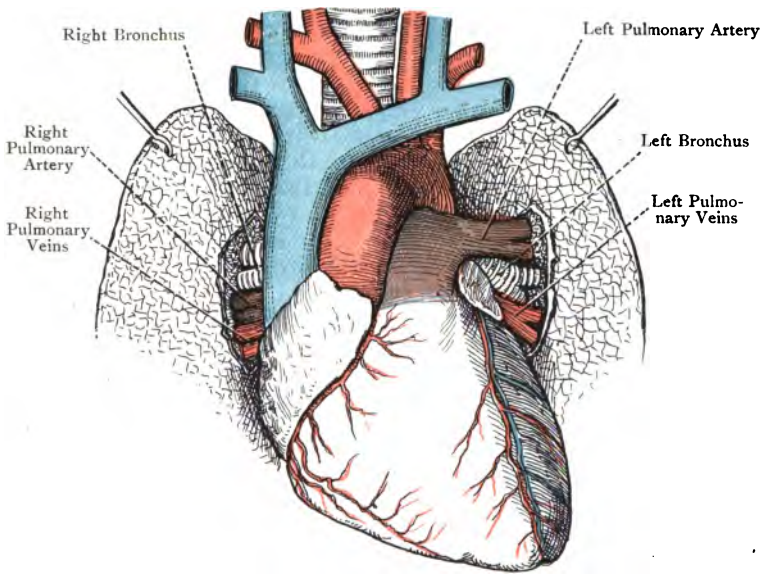


FIG. 379.—THE ROOTS OF THE LUNGS (ANTERIOR VIEW).

Superior Vena Cava. — This vessel is formed by the union of the right and left innominate veins behind the lower border of the first right costal cartilage, close to the sternum. It is about 3 inches in length, and descends almost vertically to the level of the upper border of the third right costal cartilage, where it opens into the postero-superior angle of the right auricle of the heart. In its course it pierces the fibrous portion of the pericardium. The upper half of the vessel is extrapericardial, and lies in the superior mediastinum; but the lower half is intrapericardial, and lies in the middle mediastinum.

Relations — Upper Half — *External.*— The right phrenic nerve and the right pleura. *Internal.*—The lower part of the innominate artery. **Lower Half**—*Internal.*—The ascending aorta. *Posterior.*—The root of the right lung. The serous portion of the pericardium

covers the lower part of the vessel except over about its posterior fourth.

The superior vena cava is destitute of valves.

Tributaries.—The chief tributary is the right azygos vein, after it has arched forwards over the right bronchus. It opens into the superior vena cava immediately before that vessel pierces the fibrous portion of the pericardium. Other minute tributaries are pericardial and mediastinal veins.

Development.—The portion of the superior vena cava *above* the right azygos vein is developed from that part of the right primitive jugular vein which lies below the point where it is joined by the transverse jugular vein; and the portion *below* the right azygos vein is developed from the right duct of Cuvier.

Inferior Vena Cava.—This vessel enters the thorax through the foramen quadratum in the central tendon of the diaphragm, and immediately thereafter it is received within the fibrous portion of the pericardium. Its course in the thorax is practically nil, as it may be said to open at once into the postero-inferior angle of the right auricle of the heart.

Thoracic Aorta.—The thoracic aorta extends from the base of the left ventricle of the heart to the level of the lower border of the body of the twelfth thoracic vertebra. At this point it passes through the aortic opening of the diaphragm, and thereafter enters upon the abdominal part of its course. It passes at first upwards and to the right; thereafter it sweeps, in an arched manner, upwards, backwards, and to the left, over the root of the left lung; and finally it descends in close contact with the vertebral column, lying at first upon its left side, but subsequently in front of it. It is therefore conveniently divided into three parts, namely, the ascending aorta, the arch of the aorta, and the descending aorta.

Ascending Aorta.—The ascending aorta commences at the base of the left ventricle of the heart, behind the left border of the sternum, on a level with the lower margin of the third left costal cartilage, and it terminates at a point behind the right border of the sternum on a level with the upper margin of the second right costal cartilage. Its course is upwards and to the right, with an inclination forwards. It lies in the middle mediastinum, and within the fibrous pericardium, which ensheathes it, and, for about the first 1½ inches of its course it is enclosed, along with the adjacent portion of the pulmonary artery, in a sheath formed by the serous part of the pericardium. The ascending aorta measures about 2 inches in length. At its commencement it presents three bulgings, which correspond to the sinuses of Valsalva in the interior and lie opposite the segments of the aortic valve. The bulgings are disposed as right antero-lateral, left antero-lateral, and posterior respectively. Along the right side of the vessel there is another somewhat extensive dilatation, called the *great sinus of the aorta.*

Relations—*Anterior.*—The root of the pulmonary artery and the right auricular appendix, at first, and subsequently the first piece

of the body of the sternum, from which it is separated by the pericardium, right pleura, and anterior margin of the right lung. *Posterior.*—The right pulmonary artery and the left auricle. *Right.*—The superior vena cava, and the right auricle. *Left.*—The trunk of the pulmonary artery.

Branches.—These are the two coronary arteries, right and left.

The **right coronary artery** arises from the right antero-lateral sinus of Valsalva. Passing forwards between the right auricular appendix and the root of the pulmonary artery, it enters the right auriculo-ventricular groove, which it traverses from front to back as far as the commencement of the inferior interventricular groove. At this point it divides into two branches, transverse and descending. The *transverse branch* enters the posterior part of the left auriculo-ventricular groove, in which it anastomoses with the transverse branch of the left coronary artery. The *descending branch* traverses the inferior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the left coronary artery.

The right coronary artery furnishes branches to the right auricle and to both ventricles. One, of large size, called the *right marginal branch*, passes along the right border, or margo acutus, towards the apex.

The **left coronary artery** arises from the left antero-lateral sinus of Valsalva, and is at first concealed by the root of the pulmonary artery. It then passes forwards between the pulmonary artery and the left auricular appendix, and divides into two branches, transverse and descending. The *transverse branch* enters the left auriculo-ventricular groove, which it traverses from front to back, anastomosing posteriorly with the transverse branch of the right coronary artery. The *descending branch* traverses the antero-superior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the right coronary artery.

The left coronary artery furnishes branches to the left auricle and to both ventricles. One, of large size, called the *left marginal branch*, springs from its transverse branch and passes along the left border, or margo obtusus, towards the apex.

Development.—The ascending aorta, along with the trunk of the pulmonary artery, is developed from the **aortic bulb.**

Arch of the Aorta.—The arch of the aorta commences behind the right border of the sternum, on a level with the upper margin of the second right costal cartilage, and it terminates on the left side of the body of the fourth thoracic vertebra, at the lower border of which it becomes the descending aorta. It passes upwards, backwards, and to the left, sweeping over the root of the left lung, and, when it reaches the left side of the body of the fourth thoracic vertebra, it descends. The height to which the arch reaches corresponds to the centre of the manubrium sterni, which is about

1 inch below the upper border of the manubrium. It lies in the superior mediastinum, and its left side is in close relation with the left pleura.

Relations—*Anterior.*—The left phrenic and left pneumogastric

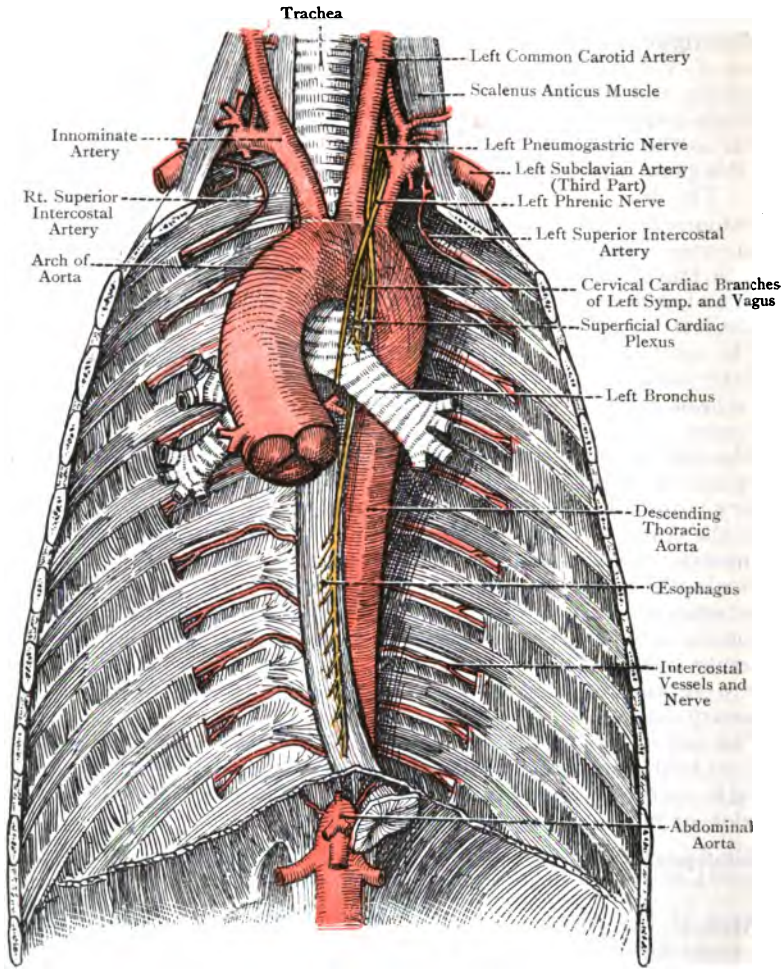


FIG. 380.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

nerves, the former being on the right side of, and anterior to, the latter. Between these two nerves are the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both on their way to the super-

ficial cardiac plexus, which they form. All these nerves are overlaid by the left pleura. Farther back than these nerves is the left superior intercostal vein. The remains of the thymus body constitute an additional anterior relation. *Posterior.*—The trachea, deep cardiac plexus of nerves, œsophagus, thoracic duct, and left recurrent laryngeal nerve. *Superior.*—The left innominate vein, and the origins of the following three great arteries, named in order from right to left, and also from before backwards: the innominate, the left common carotid, and the left subclavian. *Inferior.*—The left bronchus, the bifurcation of the pulmonary artery, the superficial cardiac plexus of nerves, the left recurrent laryngeal nerve, and the ligamentum ductûs arteriosi. The last-named fibrous cord is attached to the back part of the concavity of the arch, immediately beyond the level of the origin of the left subclavian artery.

The arch presents a constriction immediately beyond the origin of the left subclavian artery, called the *aortic isthmus*, and this is succeeded by a short fusiform dilatation, known as the *aortic spindle of His*. These conditions are best marked in the fœtus.

Branches.—These are three in number, namely, the innominate, left common carotid, and left subclavian arteries. They arise in the order named, proceeding from before backwards, and also from right to left.

Innominate Artery.—This vessel is the first and largest of the three branches which arise from the arch of the aorta. It springs from the upper aspect of the arch rather above the level of the upper border of the second right costal cartilage, and it terminates behind the upper border of the right sterno-clavicular joint by dividing into the right common carotid and right subclavian arteries. It is from 1½ to 2 inches in length, its direction is upwards and outwards, and it lies in the superior mediastinum.

Relations—*Anterior.*—The right half of the manubrium sterni, with the origins of the right sterno-hyoid and sterno-thyroid muscles; the left innominate and the right inferior thyroid veins; the right sterno-clavicular joint; and some remains of the thymus body. *Posterior.*—The trachea at first, but, as the artery ascends obliquely to the right, it leaves the front of the trachea and is placed on its right side. The three cervical cardiac branches of the right sympathetic also lie behind the artery on their way to the deep cardiac plexus. *Right.*—The right pleura; the innominate vein, with the right pneumogastric nerve behind it; the superior vena cava; and the right phrenic nerve. *Left.*—The left common carotid artery, and the trachea, in this order from below upwards.

Branches.—These are terminal, and are two in number, namely, the right common carotid and the right subclavian. The artery, as a rule, gives off no branches in its course. Occasionally, however, it gives origin to a vessel, of variable size, called the *arteria thyroidea ima* (lowest thyroid artery). The interest attached to this occasional branch is that, in ascending to the isthmus of the

thyroid body in the neck, it lies in front of the trachea, and would be endangered in performing the low operation of tracheotomy.

Varieties.—(1) The innominate artery may be shorter or longer than usual. (2) In cases of high bifurcation the artery may so encroach upon the trachea as endangered in performing the low operation of tracheotomy.

Left Common Carotid Artery in the Thorax.—This vessel arises from the upper aspect of the arch of the aorta, just to the left of, and posterior to, the origin of the innominate artery. It lies in the superior mediastinum, and its direction is upwards and to the left. Having reached the posterior aspect of the left sterno-clavicular joint, it enters upon the cervical part of its course.

Relations—*Anterior.*—The left half of the manubrium sterni, with the origins of the left sterno-hyoid and sterno-thyroid muscles, but these structures lie at a little distance from the vessel; the left innominate vein; and some remains of the thymus body. *Posterior.*—The trachea at first, and subsequently the œsophagus (which here deviates slightly to the left of the trachea), and the thoracic duct. *Right.*—The innominate artery at first, and thereafter the trachea. *Left.*—The left pneumogastric and left phrenic nerves, with the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric; and the left pleura and lung.

The thoracic portion of the left subclavian artery is on the left of, and posterior to, the vessel, but at a little distance from it.

The thoracic portion of the left common carotid artery gives off no branches.

First Part of the Left Subclavian Artery in the Thorax.—This vessel arises from the upper aspect of the arch of the aorta, a little to the left of, and posterior to, the origin of the left common carotid artery. It lies deeply in the superior mediastinum, and is almost parallel to the thoracic portion of the left common carotid, its course being nearly vertical.

Relations—*Anterior.*—The left common carotid artery; the left pneumogastric and left phrenic nerves, with the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, all these nerves lying between it and the left common carotid artery; and the left innominate vein. *Posterior.*—The œsophagus, and the thoracic duct. *Right.*—The trachea, and the left recurrent laryngeal nerve. *Left.*—The left pleura, and the inner aspect of the left lung, the latter being grooved by the vessel.

The thoracic portion of the left subclavian artery gives off no branches.

Varieties of the Aorta—1. **Position.**—(*a*) The arch of the aorta may rise as high as the upper border of the manubrium sterni, or it may stop short of the level of the centre of the manubrium. (*b*) It may be a right aortic arch, instead of a left, in which cases there may, or may not, be a transposition of the viscera. The presence of a right aortic arch is due to its formation from the fourth right arterial arch, and the persistence of the right primitive dorsal aorta.

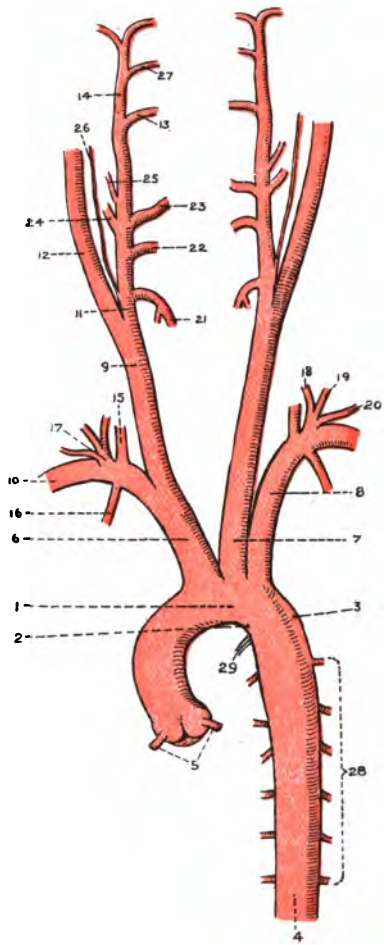


FIG. 381.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Internal Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyroid Axis
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Aortic Intercostals
29. Lig. Ductûs Arteriosi

2. **Branches of the Arch and their Positions.**—Varieties in these respects are very numerous. The normal number of branches arising from the arch is three. There may, however, be four. The most common additional branch is the **left vertebral artery,** its place of origin being between the left common carotid and left subclavian arteries. The right vertebral artery sometimes arises from the arch, but this is somewhat rare. An **arteria thyroidea ima** may arise from the arch between the innominate and left common carotid arteries. In rare cases the **internal mammary artery,** or the **inferior thyroid,** may spring from the arch. The innominate artery may be absent, in which cases the right subclavian and right common carotid have independent origins. Under these circumstances the **right subclavian artery** may be the last of the branches from the upper part of the arch, and, when this is so, in order to reach the right side of the neck, it crosses in front of the vertebral column, lying behind the œsophagus, or between the trachea and the œsophagus.

Development of the Arch of the Aorta and its Branches.—As already stated, the **ascending aorta** is developed, along with the **pulmonary artery,** from the *aortic bulb.* The **arch of the aorta** is developed chiefly from the *fourth left arterial arch,* but slightly also from the *root of the left primitive ventral aorta,* that is, the part as high as the fourth left arterial arch.

The **innominate artery** is developed from the *root of the right primitive ventral aorta*—that is, the part as high as the fourth right arterial arch.

The **left common carotid artery** is developed from *that portion of the left primitive ventral aorta which lies between the fourth and third left arterial arches.*

The **left subclavian artery** is developed from a segmental artery.

For the description of the **descending aorta,** see p. 949.

Pulmonary Artery.—This is the great vessel which, by means of its right and left divisions, carries the venous blood from the right ventricle of the heart to the lungs. It is therefore an example of an artery which conveys venous blood, and in this respect resembles the hypogastric and umbilical arteries of the fœtus. It arises from the infundibulum, or conus arteriosus, of the right ventricle of the heart, on a level with the upper margin of the third left costal cartilage at its junction with the sternum. It is directed upwards and backwards, and, after a course of about 2 inches, breaks up into two divisions, right and left, within the concavity of the arch of the aorta. The vessel lies in the middle mediastinum, and, along with the ascending aorta, it is contained within the pericardium, the serous portion of which forms one common sheath for the two arteries over about the first 1½ inches of their course.

Relations—*Anterior.*—The sternal extremity of the second left intercostal space and second left costal cartilage; and the left pleura and left lung. *Posterior.*—The root of the ascending aorta; the commencement of the left coronary artery; and the left auricle of the heart. *Right.*—The right coronary artery; the right auricular appendix; and the ascending aorta. *Left.*—The left coronary artery; and the left auricular appendix.

The only **branches** of the artery are the two terminal divisions.

The **right pulmonary artery** passes outwards to the right, behind the ascending aorta and superior vena cava, to the root of the right lung, where it divides into two branches, upper and lower. The upper branch is distributed to the upper lobe, and the lower branch, which is the larger of the two, is distributed to the middle and lower lobes.

The **left pulmonary artery** passes outwards to the left, in front of the left bronchus and descending aorta, to the root of the left lung, where it divides into two branches, one for the upper, and the other for the lower, lobe. The ligamentum ductûs arteriosi is attached to the upper aspect of its root.

The *right* pulmonary artery is larger and longer than the left.

Development.—The **trunk of the pulmonary artery**, along with the ascending aorta, is chiefly developed from the *aortic bulb*, but a small portion of it is formed by the *commencement of the sixth left arterial arch*, which remains connected with that portion of the aortic bulb which becomes partitioned off to form the pulmonary trunk.

The **right** and **left pulmonary arteries** are developed as branches from the *sixth left arterial arch near its commencement*, the remainder of that arch giving rise to the ductus arteriosus of the fœtus.

Ligamentum Ductûs Arteriosi.—This is a fibrous cord which is the remains of an important vessel, peculiar to fœtal life, called the *ductus arteriosus*. It extends from the upper aspect of the root of the left pulmonary artery to the under surface of the arch of the aorta, immediately beyond the level of the origin of the left subclavian artery. Its direction is upwards, backwards, and slightly to the left.

During fœtal life the right and left pulmonary arteries are of small size, and the ductus arteriosus conveys the greater part of the venous blood from the right ventricle of the heart into the aorta at a point *beyond* the origin of the left subclavian artery. None of this blood, therefore, can pass into the great vessels which spring from the upper aspect of the arch of the aorta.

Pulmonary Veins.—These vessels carry the arterial or oxygenated blood from the lungs to the left auricle of the heart. Though they are called veins, they contain arterial blood, and in this respect resemble the umbilical vein of the fœtus. They are four in number, two right and two left, and, at the root of each lung, the upper of the two is on a more anterior plane than the lower. The *right veins* pass behind the superior vena cava and the right auricle, and the *left veins* pass in front of the descending aorta. All four vessels open into the left auricle on its posterior aspect. On leaving the roots of the lungs the veins are said to receive small bronchial tributaries from the adjacent bronchial tubes and glands.

The *right* pulmonary veins are larger and longer than those of the left side.

Pneumogastric Nerves in the Thorax.—These nerves, right and left, differ so much from each other in their course and relations as to require separate descriptions.

The **right pneumogastric,** or **vagus, nerve,** having descended in front of the first part of the right subclavian artery, and having given off its inferior or recurrent laryngeal branch at the lower border of that vessel, enters the thoracic cavity. It then descends in the superior mediastinum behind the innominate vein, and, inclining backwards, it reaches the right side of the trachea, along which it courses to the *posterior aspect* of the root of the right lung. Behind the root of the right lung the nerve becomes flattened out

and breaks up into numerous branches, which are disposed in a plexiform manner, and constitute the *right posterior pulmonary plexus*, from which branches are given off to the right lung. From the lower part of this plexus the nerve issues in the form of two cords, which descend in the posterior mediastinum upon the right side of the œsophagus, or gullet, and communicate freely with the corresponding cords of the left side. In this manner a plexus is formed, which is called the *plexus gulæ*. Subsequently the two cords of the right side unite to form a single nerve, which descends on the *posterior surface* of the œsophagus, and enters the abdomen through the œsophageal opening of the diaphragm to be distributed to the *posterior surface* of the stomach.

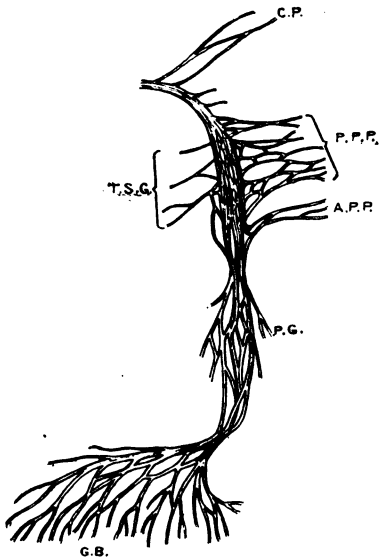


FIG. 382.—SCHEME OF PNEUMOGASTRIC NERVE IN THORAX AND ABDOMEN (FLOWER).

C.P. Branches to Cardiac Plexus
P.P.P. Branches to Posterior Pulmonary Plexus
A.P.P. Branches to Anterior Pulmonary Plexus
T.S.G. Branches from Upper Thoracic Ganglia of Sympathetic
P.G. Plexus Gulæ
G.B. Gastric Branches

The **left pneumogastric, or vagus, nerve** enters the thoracic cavity between the left common carotid and left subclavian arteries, and descends in the superior mediastinum behind the left innominate vein. It then passes in front of the arch of the aorta, having the left phrenic nerve on its right side and anterior to it, with the intervention of the superior cervical cardiac branch of the left sympathetic and its own inferior cervical cardiac branch. At the lower border of the arch it gives off its inferior or recurrent laryngeal branch, and then passes to the *posterior aspect* of the root of the left lung. Behind the root of the left lung the nerve, as on the right side, becomes flattened out and breaks up into numerous branches, which are disposed in a plexiform manner, and constitute the *left posterior pulmonary plexus*, from which branches are given off to the left lung. From the lower part of this plexus the nerve, as on the right side, issues in the form of two cords, which descend in the posterior mediastinum upon the left side of the œsophagus or gullet, and communicate freely with the corresponding cords of the right side. In this manner, as stated, a plexus is formed, which is called the *plexus gulæ*. Subsequently the two cords of the left side unite to form a single nerve, which descends on the *anterior*

surface of the œsophagus, and enters the abdomen through the œsophageal opening of the diaphragm, to be distributed to the *anterior surface* of the stomach.

Differences between the Right and Left Pneumogastric Nerves.

Right Pneumogastric Nerve.	Left Pneumogastric Nerve.
1. Descends in front of first part of right subclavian artery.	1. Descends between left common carotid and left subclavian arteries.
2. Gives off its recurrent laryngeal branch at lower border of right subclavian artery.	2. Passes behind left innominate vein.
3. Lies behind right innominate vein.	3. Crosses in front of arch of aorta.
4. Lies on right side of trachea.	4. Gives off its recurrent laryngeal branch at lower border of arch.
5. Lies at first on right side of œsophagus, and then behind it.	5. Lies at first on left side of œsophagus, and then in front of it.
6. Ramifies on posterior surface of stomach.	6. Ramifies on anterior surface of stomach.

Branches.—These are as follows : the left inferior or recurrent laryngeal ; cardiac, from the right nerve ; pulmonary ; œsophageal ; and pericardial.

The *left inferior* or *recurrent laryngeal nerve* arises from the left pneumogastric in front of the arch of the aorta, on a level with its lower border. It passes backwards within the arch at the place of attachment of the ligamentum ductûs arteriosi, and then it turns upwards behind the arch. Having reached the groove between the trachea and the œsophagus, it ascends therein to the neck, where its subsequent course and distribution will be described. In the thorax the nerve, which contains fibres derived from the bulbar or accessory portion of the spinal accessory nerve, furnishes a few cardiac branches to the deep cardiac plexus as it winds round the arch of the aorta.

The right inferior or recurrent laryngeal nerve is extra-thoracic, inasmuch as it arises from the right pneumogastric at the root of the neck, and it winds round the first part of the right subclavian artery.

The recurrent course of the right and left recurrent laryngeal nerves is brought about by the change in position which the heart and great vessels undergo in the course of development. In early embryonic life each recurrent laryngeal nerve passes inwards to the larynx below the corresponding sixth arterial arch. This arch on the right side, together with the fifth, disappears, and the right recurrent laryngeal nerve then becomes related to the fourth right arterial arch, from which the first part of the right subclavian artery is developed. The sixth left arterial arch gives rise to the ductus arteriosus, which, however, becomes obliterated, and then the left recurrent laryngeal nerve becomes related to the fourth left arterial arch (the fifth having disappeared) at the place where it receives the ductus arteriosus, and from this fourth left arch the arch of the aorta is developed. As the heart and great vessels descend from the neck into the thorax each recurrent laryngeal

nerve is necessarily drawn downwards, and the right nerve becomes recurrent round the first part of the right subclavian artery (the original fourth right arterial arch), whilst the left nerve becomes recurrent round the arch of the aorta (the original fourth left arterial arch) at the place of attachment of the ligamentum ductûs arteriosi.

The *cardiac branches* of the **right** pneumogastric are two or three in number, and they descend upon the trachea to the deep cardiac plexus. (The cardiac branches on the left side are derived, as stated, from the left recurrent laryngeal nerve as it winds round the arch of the aorta).

The *pulmonary branches* are arranged in two sets, anterior and posterior. The *anterior pulmonary branches* are two or three in number, and arise from the parent trunk before it disappears behind the root of the lung. They pass to the anterior aspect of the root, and, being joined by sympathetic twigs, they form the **anterior pulmonary plexus,** which is reinforced by twigs from the deep cardiac plexus, and, in the case of the left anterior pulmonary plexus, by twigs from the superficial cardiac plexus. The branches of the anterior pulmonary plexus enter the lung, and accompany the ramifications of the bronchial tubes.

The *posterior pulmonary branches* arise from the pneumogastric nerve behind the root of the lung. They are larger and more numerous than the anterior branches, and, being joined by twigs from the second, third, and fourth thoracic sympathetic ganglia, they form the **posterior pulmonary plexus.** The branches of this plexus, like those of the anterior, enter the lung, and accompany the ramifications of the bronchial tubes.

The *œsophageal branches* arise chiefly from the plexus gulæ, below the level of the roots of the lungs, and they are distributed to the portion of the œsophagus which occupies the posterior mediastinum. Other œsophageal branches, however, arise above the level of the roots of the lungs, and are distributed to the portion of the œsophagus which occupies the superior mediastinum.

The *pericardial branches* arise from the plexus gulæ, and are distributed to the pericardium, which they enter from behind.

Summary of Branches.

Right Pneumogastric Nerve.	**Left Pneumogastric Nerve.**
Cardiac.	Recurrent Laryngeal (which gives off Cardiac branches).
Anterior Pulmonary.	Anterior Pulmonary.
Posterior Pulmonary.	Posterior Pulmonary.
Œsophageal.	Œsophageal.
Pericardial.	Pericardial.

Cardiac Plexus.—The cardiac plexus is one of three large prevertebral plexuses associated with the sympathetic system, the other two, namely, the epigastric or solar and the hypogastric, being situated in the abdominal cavity. The plexus is situated partly in the concavity of the arch of the aorta, and partly upon

the trachea above the bifurcation and behind the aortic arch. It is formed by branches of the pneumogastric and sympathetic nerves, and consists of two portions, superficial and deep, which communicate with each other.

The **superficial cardiac plexus,** which is comparatively small, is situated in the concavity of the arch of the aorta, between the ligamentum ductûs arteriosi and the right pulmonary artery. It is formed by (1) the superior cervical cardiac branch of the *left* sympathetic, and (2) the inferior cervical cardiac branch of the left pneumogastric, nerves. These two nerves descend over the arch of the aorta, lying between the left phrenic and left pneumogastric nerves. At the place where the two nerves join there may be a small ganglion, which is known as the *ganglion of Wrisberg.*

Branches.—The plexus gives branches to the left anterior pulmonary plexus, and, having received a considerable accession of fibres from the right half of the deep cardiac plexus, it is prolonged into the *right* coronary plexus.

The **deep cardiac plexus,** of larger size than the superficial, is situated upon the trachea immediately above the bifurcation and behind the arch of the aorta. It is formed by (1) all the **cervical** cardiac branches of the *right* sympathetic, namely, superior, middle, and inferior, and of the *right* pneumogastric, namely, superior and inferior; (2) one or two cardiac branches from the *right* recurrent laryngeal nerve; (3) one or two **thoracic** cardiac branches from the *right* pneumogastric; (4) the middle and inferior cervical cardiac branches of the *left* sympathetic; (5) the superior cervical cardiac branch of the *left* pneumogastric; and (6) the thoracic cardiac branches of the *left* recurrent laryngeal nerve. It is arranged in two halves, right and left, which communicate with each other; the right half also gives a considerable accession of fibres to the superficial cardiac plexus. Each half receives the following branches:

Right Half.	Left Half.
1. The three cervical cardiac branches of the right sympathetic.	1. The middle and inferior cervical cardiac branches of the left sympathetic.
2. The two cervical cardiac branches of the right pneumogastric.	2. The superior cervical cardiac branch of the left pneumogastric.
3. The cardiac branches of the right recurrent laryngeal.	3. The cardiac branches of the left recurrent laryngeal.
4. The thoracic cardiac branches of the right pneumogastric.	

Branches.—The *right half* of the deep cardiac plexus gives off (1) branches to the right anterior pulmonary plexus; (2) branches to the right auricle of the heart; (3) branches to reinforce the right coronary plexus, which is derived, as stated, from the superficial cardiac plexus; and (4) a few branches to the left coronary plexus. The *left half* of the deep cardiac plexus gives off (1) branches to the

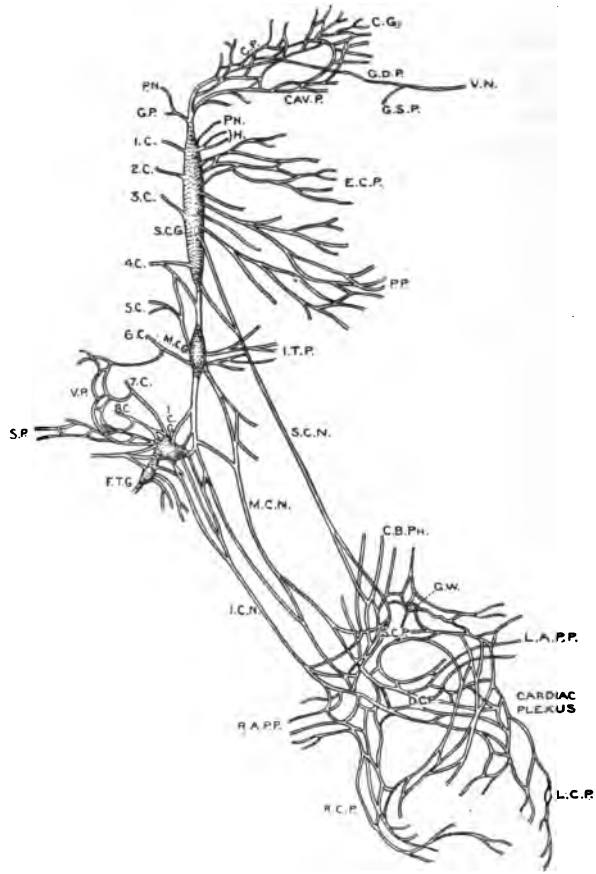


FIG. 383.—SCHEME OF THE SYMPATHETIC NERVE IN THE NECK, AND OF THE CARDIAC PLEXUS (FLOWER).

S.C.G. Superior Cervical Ganglion.

P.N. and G.P. Branches to Pneumogastric and Glosso-pharyngeal
1c, 2c, 3c, 4c. Branches to Upper Four Cervical Nerves
C.P. Carotid Plexus
Cav. P. Cavernous Plexus
C.G. Branch to Ciliary Ganglion
G.D.P. Great Deep Petrosal
G.S.P. Great Superficial Petrosal
V.N. Vidian Nerve
P.N. To Ganglion of Trunk of Pneumogastric
H. To Hypoglossal
E.C.P. To External Carotid Plexus
P.P. To Pharyngeal Plexus
S.C.N. Superior Cardiac Nerve

M.C.G. Middle Cervical Ganglion.

5c, 5c. To Fifth and Sixth Cervical Nerves
I.T.P. To Inferior Thyroid Plexus
M.C.N. Middle Cardiac Nerve

I.C.G. Inferior Cervical Ganglion.

7c, 8c. To Seventh and Eighth Cervical Nerves
V.P. To Vertebral Plexus
S.P. To Subclavian Plexus
I.C.N. Inferior Cardiac Nerve

F.T.G. First Thoracic Ganglion

Cardiac Plexus.

C.B.PN. Cardiac Branches of Pneumogastric
S.C.P. Superficial Cardiac Plexus
G.W. Ganglion of Wrisberg
D.C.P. Deep Cardiac Plexus
R.A.P.P. Right Anterior Pulmonary Plexus
L.A.P.P. Left Anterior Pulmonary Plexus
R.C.P. Right Coronary Plexus
L.C.P. Left Coronary Plexus

left anterior pulmonary plexus ; (2) branches to the left auricle of the heart ; and (3) the left coronary plexus.

Coronary Plexuses.—These are two in number, right and left.

The **right coronary plexus** is formed by branches from (1) the superficial cardiac plexus, and (2) the right half of the deep cardiac plexus. It accompanies the right coronary artery, and furnishes branches to the right auricle and right ventricle of the heart.

The **left coronary plexus** is formed by branches which are derived chiefly from the left half of the deep cardiac plexus, but it also receives a few branches from the right half. It accompanies the left coronary artery, and furnishes branches to the left auricle and left ventricle of the heart.

Ganglia are met with in the coronary plexuses, and in the course of the fibres which supply the walls of the auricles. They are also present on the fibres which supply the walls of the ventricles in the region of the auriculo-ventricular groove, but nowhere else. In the heart of the calf the nerves are easily recognised beneath the visceral layer of the pericardium, as they pass across the muscular fibres in an oblique manner.

Heart.—The heart is a hollow, muscular organ, which, enclosed within the pericardium, is situated in the middle mediastinum, where it lies obliquely between the two lungs. It is conical in shape, and is free to move within its pericardial sac, except at the base, where it is connected with the great bloodvessels. Its relation to the thoracic wall, during life, is influenced by posture and by the respiratory movements. When a person lies upon the left side, or when the prone position is assumed, the organ is more intimately related to the thoracic wall than in the opposite postures ; and during inspiration it is less intimately connected with the thoracic wall than during expiration.

General Relations and Topography.—The heart lies obliquely behind the lower three-fourths of the body of the sternum. About two-thirds of the organ are contained in the left half of the thoracic cavity, and about one-third in the right half. The *base* is directed upwards, backwards, and to the right, and lies opposite the bodies of the middle four thoracic vertebræ, namely, the fifth, sixth, seventh, and eighth. The *apex* is directed downwards, forwards, and to the left, and, during life, it strikes the thoracic wall in the fifth left intercostal space, 1½ inches below the left nipple, and about ¾ inch within the left mammillary line. This point represents the apex-beat, and is about 3½ inches from the median line of the sternum. The *antero-superior surface*, which is convex, lies behind the lower three-fourths of the body of the sternum and the corresponding costal cartilages, right and left, namely, the third, fourth, fifth, and sixth, more particularly those of the left side. This surface is encroached upon by the pleuræ and the thin anterior margins of the lungs. Opposite the cardiac notch on the anterior margin of the left lung there is a small portion which is uncovered by lung, unless during deep inspiration, and this cor-

responds with the *area of precordial dulness*. **Latham's circle** is taken as defining this area, and the directions for describing the circle are as follows: 'Make a circle of 2 inches in diameter round a point midway between the left nipple and the end of the sternum.' Strictly speaking, the area of precordial dulness is triangular in conformity to the V-shaped cardiac notch on the anterior margin of the left lung, and it may be mapped out by the following lines: one drawn from the position of the apex-beat to the median line of the sternum on a level with the fourth left costal cartilage; another drawn from the position of the apex-beat to the median line of the sternum at the junction of the body and ensiform process; and a third connecting the mesial ends of these two lines, and extending along the middle of the sternum. The *inferior* or *diaphragmatic surface*, which is flat, is directed downwards, and rests upon the upper surface of the central tendon of the diaphragm, covered by the serous portion of the pericardium.

The outline of the heart, in reference to the anterior wall of the thorax, may be indicated, with approximate accuracy, in the following manner:

Base.—Draw a line across the sternum on a level with the upper border of the third right, and the lower border of the second left, costal cartilages, and prolong this line for ½ inch to the right of the sternum, and 1 inch to the left of it.

Inferior (Right) Border, or *Margo Acutus.*—Draw a line from the sternal end of the sixth right costal cartilage to the position of the apex-beat. This line corresponds to the lower limit of the heart.

Right Limit.—Draw a line from the upper border of the third right costal cartilage, ½ inch from the sternum, to the sternal end of the sixth right costal cartilage. This line should be curved outwards to such an extent that its greatest convexity will be 1½ inches distant from the median line of the sternum. It corresponds with the right limit of the right auricle.

Left Border, or *Margo Obtusus vel Rotundus.*—Draw a line from the lower border of the second left costal cartilage, 1 inch from the sternum, to the position of the apex-beat. This line should be slightly curved outwards, but it must not include the left nipple. It corresponds to the left limit of the heart.

Course of the Circulation.—The interior of the heart is divided by two septa (interauricular and interventricular) into two halves, right and left, and each half is subdivided by a transverse constriction into two chambers, an upper or auricle, and a lower or ventricle, right and left respectively. The auricles, except in the fœtus, are completely separated from each other by a septum, and so also are the ventricles; but the auricle and ventricle of each side communicate freely with each other by the auriculo-ventricular orifice. The right auricle receives the venous blood chiefly from the superior and inferior venæ cavæ and the coronary sinus. From the right auricle the blood passes into the right ventricle, and thence into the trunk of the pulmonary artery. The right and

left pulmonary arteries convey it to the lungs, and in passing through the pulmonary capillaries it is oxygenated and becomes arterial blood. It is then taken up by the pulmonary venous radicles, and conveyed to the pulmonary veins, which carry it to the left auricle of the heart. From the left auricle it passes into the left ventricle, whence it is driven into the aorta. The aorta and its various ramifications convey the arterial blood to the different parts of the body, and thereafter it is returned as venous blood to the right auricle of the heart.

Exterior of the Heart.—The exterior of the heart presents distinct indications of its division internally into four chambers.

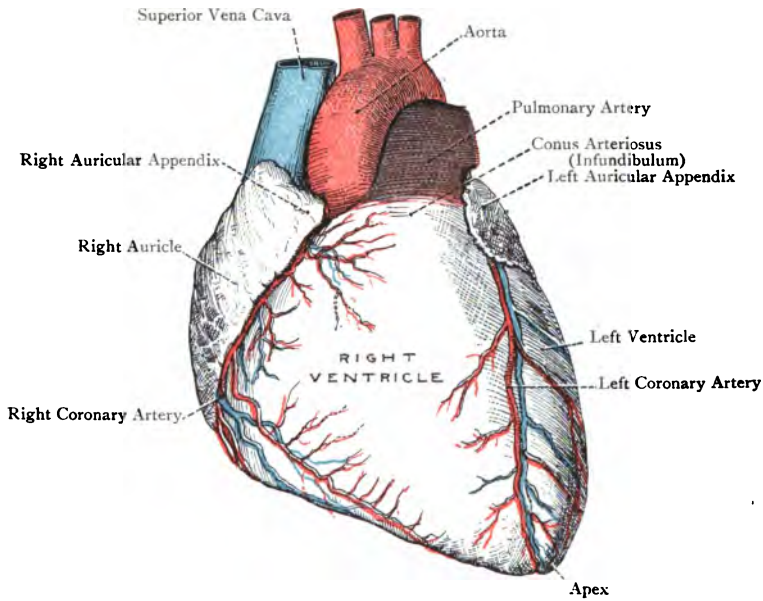


FIG. 384.—THE HEART (ANTERIOR VIEW).

These take the form of grooves, namely, auriculo-ventricular, interauricular, and interventricular.

The *auriculo-ventricular groove*, which is deep, divides the heart into auricular and ventricular portions, and it surrounds the organ except in front, where the roots of the aorta and pulmonary artery are situated. The auricular portion is posterior and superior in position, whilst the ventricular portion is anterior and inferior. The *right half* of the auriculo-ventricular groove contains (1) the right coronary artery, and (2) the right or small cardiac vein, which latter lies chiefly in its posterior part. The *left half* of the auriculo-ventricular groove contains (1) the transverse branch of the left coronary artery, (2) the transverse branch of the right coronary

artery, which lies in its posterior part ; (3) a portion of the great cardiac or coronary vein, which lies in its anterior part, and also slightly in its posterior part ; and (4) the coronary sinus, which lies in its posterior part.

The **auricular portion** of the heart has the form of a crescent, the horns of which represent the auricular appendices, and are directed forwards. The concavity of the crescent is also directed forwards, and it lodges the roots of the aorta and pulmonary artery, the latter being the more anterior of the two. The walls of the auricular portion are thin, and it is divided into two auricles, right and left. The external indication of this division is the *interauricular groove*, which is situated vertically on the posterior surface, to the left of the openings of the superior and inferior venæ cavæ. This groove corresponds to the posterior attachment of the interauricular septum in the interior. The greater part of the posterior surface of the auricular portion is formed by the left auricle. The large posterior part of each auricle is called the *atrium* ('reception-chamber'), and projecting forwards from the anterior and upper part of each atrium there is the *auricular appendix*. The two auricular appendices embrace between them the roots of the aorta and pulmonary artery.

The **right auricle** forms the anterior and right part of the base of the heart, and is quadrangular. The superior vena cava enters its atrium at the postero-superior angle, and the inferior vena cava at the postero-inferior angle. Near the latter vein the coronary sinus also opens into the atrium. The *right auricular appendix* is prolonged forwards from the antero-superior angle of the atrium, and inclines to the left in front of the root of the ascending aorta. It is shorter, broader, and less curved than the left auricular appendix, and its margin is notched, but not so much so as in the left appendix. The right auricle is traversed by a groove, called the *sulcus terminalis*, which extends from the front of the termination of the superior vena cava to the right side of the termination of the inferior vena cava. This groove indicates where the *saccus reuniens* of embryonic life meets the primitive auricle.

The **left auricle** forms the posterior and left part of the base of the heart. It is quadrilateral, and the greater part of it lies flattened behind the ascending aorta and trunk of the pulmonary artery. The pulmonary veins, two right and two left, open into the posterior part of its atrium. The *left auricular appendix* is prolonged forwards from its left aspect, and inclines to the right over the left side of the root of the pulmonary artery. It is longer, narrower, and more curved than the right auricular appendix, and its margin is more deeply notched. The back of the left auricle is related to the œsophagus, with the intervention of the pericardium, and the small *oblique vein of Marshall* passes downwards and inwards upon it, to open into the coronary sinus.

The **ventricular portion** of the heart is conical, its walls are thick, and it is divisible into two ventricles, right and left. The ex-

ternal indication of this division is the interventricular groove, which corresponds to the attachments of the interventricular septum in the interior. This groove consists of two parts, antero-superior and inferior. The *antero-superior interventricular groove* extends over the antero-superior surface of the heart from the left side of the root of the pulmonary artery to the inferior border, or margo acutus, to the right of, and near, the apex. At this point it becomes continuous with the inferior interventricular groove. It contains, besides fat, (1) the descending branch of the left coronary artery, and (2) a part of the great cardiac or coronary vein (more

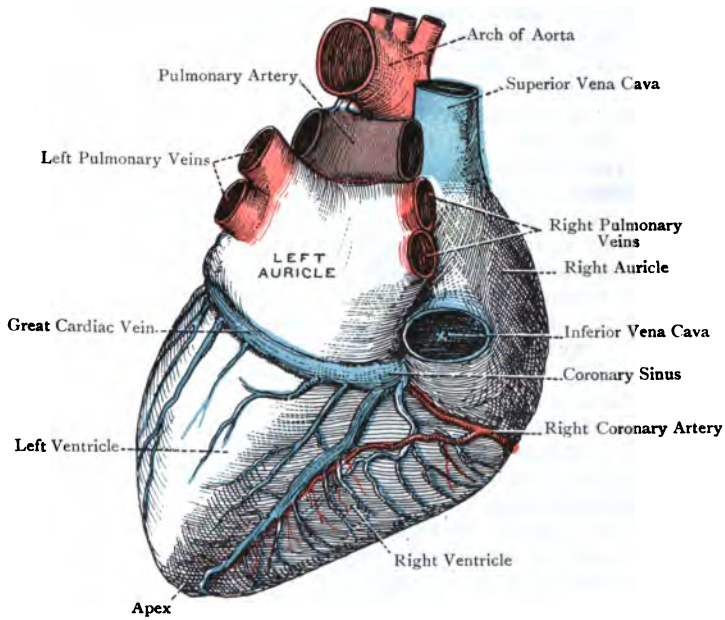


FIG. 385.—THE HEART (POSTERIOR VIEW).

properly called the antero-superior interventricular vein in this region). The *inferior interventricular groove* is situated on the inferior surface of the heart, and, as stated, is continuous with the preceding. It contains, besides fat, (1) the descending (inferior) branch of the right coronary artery, and (2) the middle cardiac vein (more properly called the inferior interventricular vein).

The ventricular portion of the heart presents an apex, a base, two surfaces, and two borders. The **apex** is directed downwards, forwards, and to the left, and forms the apex of the heart. The *left* ventricle alone enters into its formation. The **base** is directed upwards, backwards, and to the right, and is connected with the

atria of the auricles and the origins of the aorta and pulmonary artery, the former being behind, and the latter in front.

The **surfaces** are antero-superior and inferior. The *antero-superior surface* is convex, and is traversed by the antero-superior interventricular groove. As this groove lies near the left border, the greater part of this surface (about two-thirds) is formed by the right ventricle, and the remainder by the left ventricle. In *post-mortem* examinations, therefore, when the pericardium is opened, the **right** ventricle is chiefly exposed for inspection. On this aspect of the right ventricle there are the anterior cardiac veins. Its upper and left part is somewhat conical, and is called the *infundibulum* or *conus arteriosus*. It gives origin superiorly to the trunk of the pulmonary artery. The *inferior surface* is flat, and is traversed by the inferior interventricular groove. As this groove lies near the inferior border, the greater part of this surface (about two-thirds) is formed by the left ventricle, and the remainder by the right ventricle. On this aspect of the left ventricle there are the posterior cardiac veins.

The **borders** are inferior (right) and left. The *inferior border* is comparatively long, and extends from right to left. It is formed by the right ventricle, and is sharp in outline, from which circumstance it is known as the *margo acutus*. The marginal branch of the right coronary artery and one of the anterior cardiac veins lie along it. The *left border* is shorter than the inferior, and is blunt and round, from which circumstances it is known as the *margo obtusus vel rotundus*. The marginal branch of the left coronary artery lies along it.

Interior of the Heart—Right Auricle.—The wall of the auricular appendix is marked by a number of muscular elevations, arranged as closely-set, vertical, parallel bands, like the teeth of a comb, from which circumstance they are called the *musculi pectinati*. These bands, relatively to each other, are more or less reticular. They are also present on the right wall of the atrium, being more comb-like here than in the appendix, and they terminate posteriorly at a vertical ridge, called the *crista terminalis*. This crest corresponds in position to the sulcus terminalis externally, and it has the same significance. Internally and posteriorly the walls of the auricular atrium are destitute of musculi pectinati, and present a smooth appearance. The atrium of the right auricle presents the following **openings**: the opening of the superior vena cava; the opening of the inferior vena cava; the opening of the coronary sinus; the foramina Thebesii; and the auriculo-ventricular opening.

The **orifice of the superior vena cava,** which is destitute of a valve, is situated at the postero-superior angle of the atrium. It is directed downwards and forwards, and the upper part of the crista vestibuli is continuous with its anterior margin.

The **orifice of the inferior vena cava** is situated at the postero-inferior angle of the atrium, and is directed upwards and inwards. In front of the orifice, and to a certain extent overlapping it, there

is a crescentic fold of endocardium, which is the remains of the *Eustachian valve* of fœtal life. The convexity of the crescent is continuous with the anterior margin of the orifice of the vein, and the inner horn of the crescent is continuous with the anterior limb of the annulus ovalis, to be presently described. The fold is a somewhat indefinite structure in the adult, being subject to much variety as regards size, and sometimes presenting several small openings. During fœtal life, however, the Eustachian valve is of the utmost importance, inasmuch as it directs the blood entering by the inferior vena cava through the foramen ovale into the left auricle.

The **orifice of the coronary sinus** is situated between the vestigial Eustachian valve and the auriculo-ventricular orifice. It is

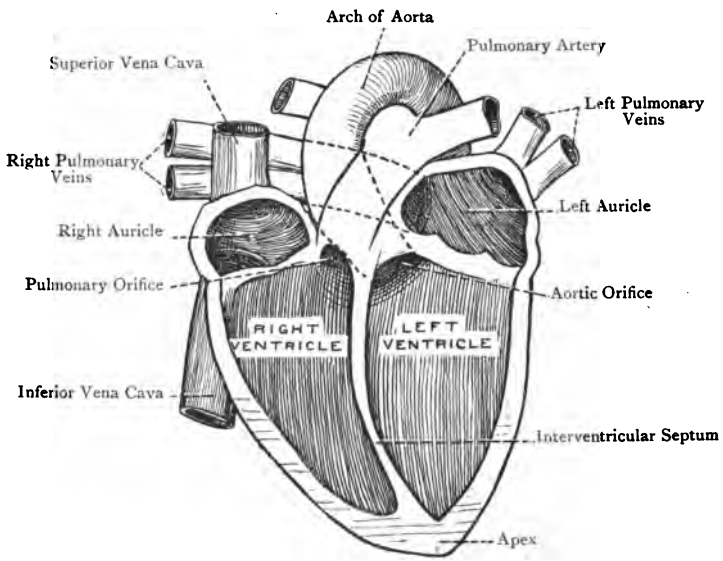


FIG. 386.—DIAGRAMMATIC VIEW OF THE INTERIOR OF THE HEART (AFTER MILNE EDWARDS).

guarded by a delicate semicircular fold of the endocardium, called the *coronary valve*, or *valve* of *Thebesius*, which, however, is functionally incompetent.

The **foramina Thebesii** represent several minute openings on the wall of the atrium. Some of these are simply blind recesses, whilst others are the orifices of minute veins, called the *venæ minimæ cordis*, which return the blood from the wall of the auricle.

The **auriculo-ventricular,** or **tricuspid, orifice** is situated in the lower and anterior part of the atrium, in front of the orifice of the inferior vena cava, with the intervention of that of the coronary sinus. It is oval, and, in health, the index, middle, and ring fingers,

held close together and side by side, can be passed through it without difficulty. Through this opening the blood passes from the right auricle into the right ventricle, its return being prevented by the tricuspid valve, which will be described in connection with the right ventricle.

The so-called *tubercle of Lower* is an unimportant slight projection, which is situated on the interauricular septum, just below the opening of the superior vena cava and behind the upper part of the fossa ovalis.

The posterior wall of the atrium corresponds to the *interauricular septum*, and it presents for consideration the fossa ovalis and the annulus ovalis.

The **fossa ovalis** is an oval depression which is situated upon the lower part of the interauricular septum, a little above and to the left of the orifice of the inferior vena cava. It indicates the position of the *foramen ovale* of the fœtal heart, which is a communication between the two auricles through which the blood entering the right auricle by the inferior vena cava passes into the left auricle. The floor of the fossa ovalis is very thin, and is bounded above and at the sides by a prominent, crescentic margin, called the **annulus ovalis.** The annulus is deficient below, and the concavity of the crescent is directed downwards. Its anterior limb is continuous with the vestigial Eustachian valve. In some cases a minute oblique communication between the two auricles persists in the adult, being situated under cover of the upper portion of the annulus ovalis.

Interior of the Right Ventricle.—When exposed to view in the ordinary way the interior of the right ventricle is triangular, the base being directed backwards and upwards, and the apex forwards and downwards. It is completely separated from the left ventricle by the interventricular septum, which forms the posterior wall of the ventricle, and bulges into it so as to be convex towards it. In transverse section, therefore, the right ventricle is semilunar. Its wall, which is about three times thinner than that of the left ventricle, is thickest at the base, and becomes thinner towards the apex. The capacity of the ventricle is about 4 ounces. Its upper and left part forms the *infundibulum* or *conus arteriosus*, from the upper part of which the trunk of the pulmonary artery springs. The walls of the infundibulum are smooth, but elsewhere the walls of the ventricle are elevated into muscular bands, called *columnæ carneæ*. These project into the cavity, and, from their reticular arrangement, they render the wall very irregular. According to the manner in which the columnæ corneæ are attached to the wall, they are arranged in three sets: (1) some are simple elevations, which are attached to the wall by their entire length, as well as by their extremities; (2) some are attached to the wall only by their extremities, being free elsewhere; and (3) others are attached only by one extremity. These latter are called *musculi papillares*. They are conical, and their bases are attached to the

wall of the ventricle. Their free extremities are connected with a number of filiform processes, called *chordæ tendineæ*, which pass to the margins and ventricular surfaces of the segments of the auriculo-ventricular valve. When the ventricle contracts, the musculi papillares also contract, and, by tightening the chordæ tendineæ, they prevent the segments of the auriculo-ventricular valve from being driven back into the auricle. The segments are therefore maintained in contact during the ventricular systole, and no regurgitation of blood from the ventricle into the auricle is allowed, in health. The musculi papillares are arranged in two groups, anterior and posterior, and their bases are attached to the

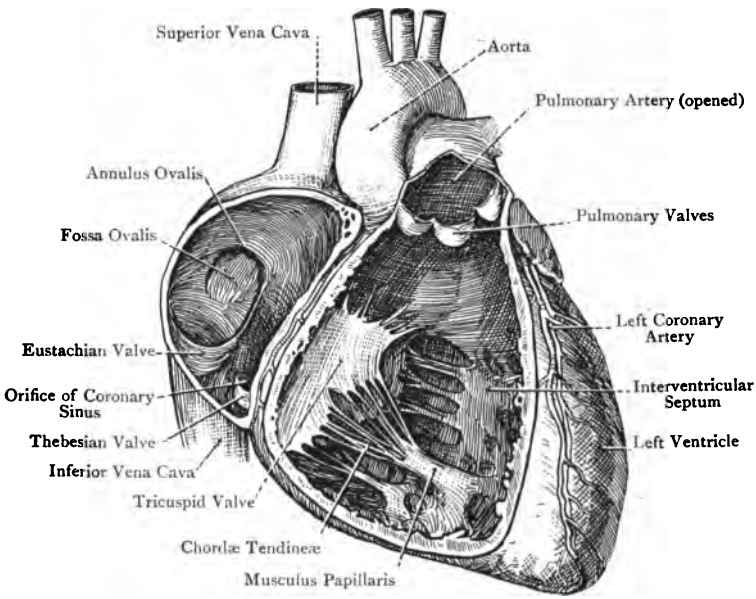


FIG. 387.—THE INTERIOR OF THE RIGHT AURICLE AND RIGHT VENTRICLE.

wall of the ventricle in the region of the apex of the cavity. The anterior musculus papillaris is of large size, and the posterior is usually broken up into two or more secondary papillary muscles.

In most hearts a fleshy column, called the *moderator band*, is met with in the right ventricle, which extends from the interventricular septum to the base of the anterior papillary muscle. It is regarded as controlling distension of the right ventricle, which it effects by the influence it exerts upon the anterior wall.

The **openings** connected with the right ventricle are two in number, namely, the auriculo-ventricular and pulmonary. They are situated at the base of the cavity, and are guarded by most important valves. The auriculo-ventricular orifice is situated on the

right and posteriorly, whilst the pulmonary orifice is situated on the left and anteriorly, being also on a higher level than the other. *Venæ minimæ cordis* are said to open into the right ventricle.

The **auriculo-ventricular,** or **tricuspid, orifice** is, as already stated in connection with the right auricle, oval, and it readily admits the index, middle, and ring fingers held close together. It allows the venous blood to flow from the right auricle into the right ventricle, and, in order to prevent regurgitation of blood from the ventricle into the auricle during the ventricular systole, it is guarded by an important valve, called the **right auriculo-ventricular** or **tricuspid valve.** This valve is composed of three segments or *cusps*, which are covered with endocardium. These project into the cavity of the ventricle, and are triangular. The bases of the cusps are continuous with one another, and form a ring, which is attached to the margin of the auriculo-ventricular orifice. The largest cusp is situated in front, and to the left, of the auriculo-ventricular orifice. It intervenes between that orifice and the infundibulum, and is known as the *left* or *infundibular cusp*. Another cus pis situated behind the auriculo-ventricular orifice, and is in contact with the interventricular septum. It is called the *posterior* or *septal cusp*. The third cusp is situated to the right, near the margo acutus, and is called the *right* or *marginal cusp*. In the angular intervals between the basal parts of the three large cusps there are usually three small cusps.

Each cusp consists of two layers of endocardium, with fibrous tissue between them, especially at their central parts. The middle portion of each cusp is therefore thicker than the marginal portions, these latter being thin and transparent. The margins themselves are notched. The auricular surfaces of the cusps are smooth, but their ventricular surfaces are roughened by the chordæ tendineæ, which are also attached to the margins.

The **chordæ tendineæ** are filiform, fibrous processes which are connected, on the one hand, with the wall of the ventricle, and, on the other, with the cusps of the auriculo-ventricular valve. Most of them spring from the two papillary muscles, but a few of them arise from the interventricular septum and from small papillary eminences upon it. Those which are connected with the anterior papillary muscle pass to the interval between the infundibular and marginal cusps; those which are connected with the posterior papillary muscle and its subdivisions pass to the interval between the septal and marginal cusps; and those which are connected with the interventricular septum pass to the interval between the infundibular and septal cusps. The connection of the chordæ tendineæ with the cusps of the valve is of a threefold nature, as follows: (1) the most numerous are connected with the marginal parts of the cusps; (2) others are connected with the thickened central portion of each cusp; and (3) a few pass to the basal portion of each cusp, where they are connected with the fibrous ring around the auriculo-ventricular orifice.

The **pulmonary valve** guards the orifice of the pulmonary artery, and prevents regurgitation of blood from the trunk of the pulmonary artery into the right ventricle during the elastic recoil of the arterial wall. It is composed of three semilunar or sigmoid segments, and the wall of the artery, opposite each segment, presents a recess, these recesses being called the **sinuses of Valsalva.** The valve and the sinuses of Valsalva are similar to corresponding structures in connection with the aortic orifice, and will be fully described along with that orifice.

Interior of the Left Auricle.—The musculi pectinati are present *only* in the auricular appendix, whereas in the right auricle they are

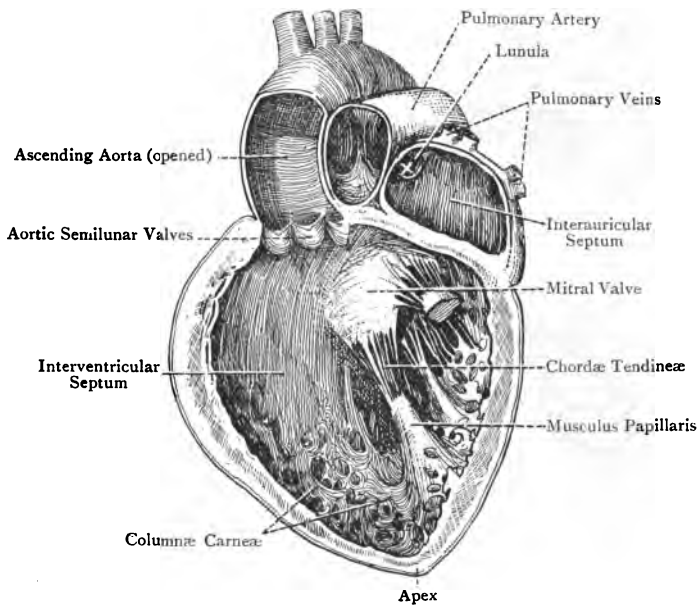


FIG. 388.—THE INTERIOR OF THE LEFT AURICLE AND LEFT VENTRICLE.

present both in the auricular appendix and on the right wall of the atrium. The wall of the left atrium is entirely smooth. The atrium presents five **openings,** namely, the openings of the four pulmonary veins, and the auriculo-ventricular opening.

The **orifices of the four pulmonary veins** are situated on the posterior wall at either side, two right and two left, and they are destitute of valves.

The **auriculo-ventricular,** or **mitral, orifice** is situated in the anterior part of the floor of the atrium. It is oval, and, in health, it admits two fingers held side by side, and in close contact.

Venæ minimæ cordis are said to open into the left auricle.

The *interauricular septum* presents a slight depression, limited inferiorly by a faint crescentic ridge, the concavity of which is directed upwards. These indicate the position of the foramen ovale of the fœtal heart.

Interior of the Left Ventricle.—The cavity of the left ventricle extends quite to the apex of the heart, and is longer and narrower than that of the right ventricle. It is somewhat conical, the base being directed backwards and upwards. The interventricular septum recedes from the cavity, and is concave towards it. In transverse section, therefore, the left ventricle is oval, or nearly circular. The wall of the left ventricle is about three times thicker than that of the right, the difference being readily accounted for by the fact that the left ventricle is concerned with the systemic circulation, whilst the right ventricle has to do with the pulmonary circulation, the latter involving a much shorter circuit. The wall of the left ventricle attains its maximum thickness about the junction of the upper fourth and lower three-fourths, and it is thinnest in the region of the apex. The capacity of the ventricle is about 4 ounces. The portion of the cavity immediately below the aortic orifice is known as the **aortic vestibule**, the walls of which are *fibrous*.

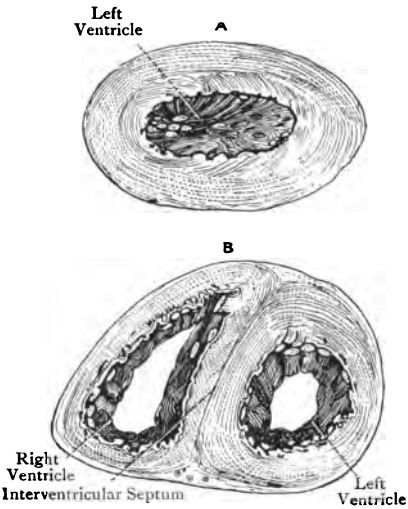


FIG. 389.—TRANSVERSE SECTIONS OF THE HEART.

A, Through Apex (Superior View).
B, Through Ventricles (Inferior View).

The left ventricle, like the right, is provided with columnæ carneæ. They are arranged in a very intricate manner, more particularly in the region of the apex and over the posterior wall. The aortic vestibule, and the interventricular septum, at least over its upper part, are destitute of columnæ carneæ, and present a smooth appearance. The musculi papillares are much larger than those in the right ventricle ; they are two in number, anterior and posterior ; and they are attached by their bases to the respective walls of the ventricle, whilst their free ends are connected with the chordæ tendineæ.

The **openings** connected with the left ventricle are two in number, namely, auriculo-ventricular and aortic. They are situated at the base of the ventricle in close proximity to each other, and are guarded by important valves. The auriculo-ventricular orifice is

situated on the left and posteriorly, whilst the aortic orifice is situated on the right and anteriorly. The aortic orifice is also the higher of the two. *Venæ minimæ cordis* are said to open into the left ventricle.

The **auriculo-ventricular,** or **mitral, orifice** is oval, and, in health, it admits two fingers held side by side. It allows the arterial blood to flow from the left auricle into the left ventricle, and, in order to prevent regurgitation of blood from the ventricle into the auricle during the ventricular systole, it is guarded by an important valve. This valve is called the **left auriculo-ventricular, mitral,** or **bicuspid valve.** It is composed of two large segments or *cusps*, with two small cusps in the angular intervals between their basal parts. The cusps are similar in shape and structure to those of the tricuspid valve, but, on account of the nature of their work, they are thicker and stronger. They are disposed obliquely, and are of unequal

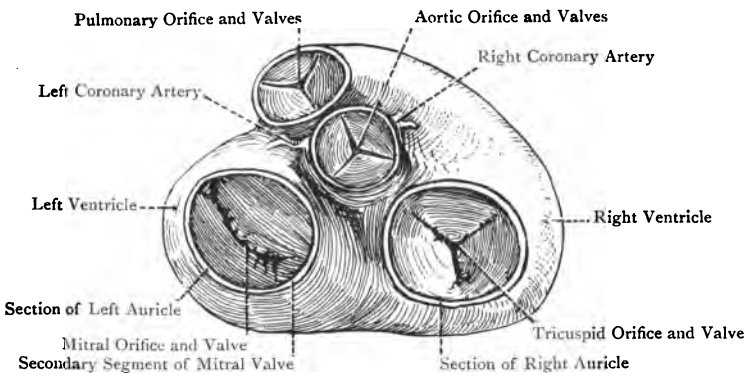


FIG. 390.—THE AURICULO-VENTRICULAR AND ARTERIAL ORIFICES OF THE HEART, WITH THEIR VALVES (SUPERIOR VIEW).

(The Auricles have been removed.)

size. The larger of the two is placed in front, and to the right, of the orifice. It intervenes between the auriculo-ventricular and aortic orifices, and is known as the *anterior* or *aortic cusp*. The smaller cusp is placed behind, and to the left, of the orifice, and is known as the *posterior* or *marginal cusp*.

The **chordæ tendineæ** are attached to the cusps, as in the case of the tricuspid valve. They are, however, fewer in number, and of greater thickness and strength, than on the right side.

Function of the Tricuspid and Mitral Valves.—These valves serve to prevent regurgitation of blood from the ventricles into the auricles during the ventricular systole. Whilst the ventricle is being filled, some of the blood gets behind the segments of the auriculo-ventricular valve, that is to say, between each segment and the wall of the ventricle, and the segments are thus carried towards the auriculo-ventricular orifice. When the ventricle is

filled with blood, the segments are in contact, and the ventricular systole now takes place. At the same time the musculi papillares contract. Blood is forced against the segments of the valve, but it cannot, in health, enter the auricle, because the segments are maintained in close contact, and are prevented from being driven back into the auricle, by the chordæ tendineæ, which are under the control of the musculi papillares. If there were no musculi papillares, in which case the chordæ tendineæ would spring directly from the wall of the ventricle, then the segments of the valve would not be held tight, but would, under the pressure of the blood, be driven back into the auricle, and regurgitation of blood would of necessity occur. The explanation of this lies in the fact that when the ventricle contracts a kind of screwing up or wringing movement takes place in its wall, as, so to speak, in wringing a wet towel. The effect of this peculiar action is to approximate successive parts of the ventricular wall to the auriculo-ventricular orifice, and this would have the effect of relaxing the chordæ tendineæ, and so allowing the segments of the valve to be driven back into the auricle. The chordæ tendineæ, however, spring from musculi papillares, and these are elevations of the wall of the ventricle, directed *towards* the auriculo-ventricular orifice. During the wringing movement, therefore, of the ventricular wall in systole the musculi papillares, as stated, contract, and so maintain the chordæ tendineæ taut, or tightly drawn.

When the mitral valve opposes the entrance of blood into the left ventricle the cardiac affection is known as mitral obstruction (stenosis). When the mitral valve is incompetent, and allows regurgitation of blood to take place from the left ventricle into the left auricle, the cardiac affection is known as mitral regurgitation (incompetence).

The **aortic orifice** is circular, and is separated from the auriculo-ventricular orifice by the anterior or aortic cusp of the mitral valve. It is guarded by the **aortic valve,** which, by means of its segments, prevents regurgitation of blood from the aorta into the left ventricle during the elastic recoil of the arterial wall. It is composed of three semilunar or sigmoid segments, consisting of fibrous tissue, covered on their ventricular surfaces by endocardium, and on their

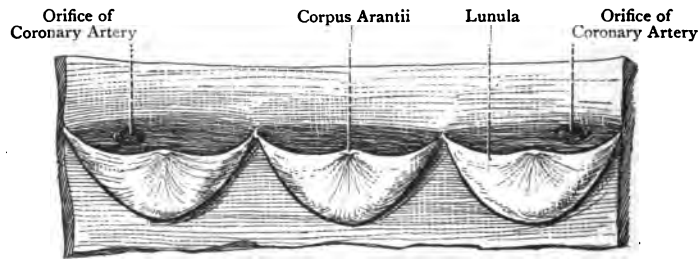


FIG. 391.—THE AORTIC SEMILUNAR VALVES.

arterial surfaces by the endothelial lining of the artery. Each segment is attached by its convex border to the wall of the artery at the place where it springs from the ventricle. The other border of the segment is free, and is directed away from the ventricle. Each segment, therefore, is so disposed as to allow the blood to pass freely into the aorta from the left ventricle. The free border of each segment is strengthened by a band of fibrous tissue, and at

the centre of the border there is a small swelling, called the *nodule* or *corpus Arantii*. This gives rise to a slight projection, and on either side of it the border is concave. The attached convex border of each segment is also strengthened by fibrous tissue. In addition to these fibrous thickenings, fibrous tissue pervades each segment from the nodule to the attached border, with the exception of the portions immediately below the lateral concave parts of the free border. These portions, in each segment, are semilunar, and are called the *lunulæ*. They are the thinnest parts of the segment, and are transparent, consisting practically of endocardium and the endothelial lining of the artery.

The interior of the wall of the aorta presents three well-marked recesses, each of which is placed opposite a segment of the valve. These recesses are called the **sinuses of Valsalva,** and they are disposed as *right antero-lateral*, *left antero-lateral*, and *posterior*, respectively. The right antero-lateral sinus of Valsalva presents the orifice of the right coronary artery, and the left antero-lateral sinus of Valsalva presents the orifice of the left coronary artery. Each sinus of Valsalva, together with the corresponding segment of the aortic valve, forms a small pocket, and the three pockets open away from the left ventricle, that is to say, in a direction corresponding to the normal blood-flow.

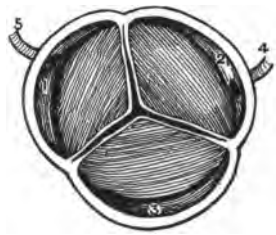


FIG. 392.—THE SEMILUNAR VALVES OF THE AORTA (SUPERIOR VIEW).

1, Left Antero-lateral Sinus of Valsalva; 2, Right Antero-lateral Sinus of Valsalva; 3, Posterior Sinus of Valsalva; 4, Right Coronary Artery; 5, Left Coronary Artery.

Function of the Aortic Valve.—This valve serves to prevent regurgitation of blood from the aorta into the left ventricle during the elastic recoil of the arterial wall close to the heart. During the ventricular systole, when the blood is being driven through the aortic orifice, the aortic valve is passive, and its three segments are applied to the arterial wall. During the elastic recoil of the arterial wall, however, the valve is in action. The first effect of the elastic recoil is to force sufficient blood backwards towards the left ventricle to close the aortic valve. This blood enters the pockets formed by the sinuses of Valsalva and the segments of the valve. The segments are pressed towards the centre of the aortic orifice, and they come into contact in the following manner: the three nodules or corpora Arantii come into close contact at the centre of the aortic orifice, and so close what would otherwise be a small space, and the respective lunulæ are closely pressed against one another. In this manner the aortic orifice is completely closed, and regurgitation of blood into the left ventricle is, in health, effectually guarded against. It will be evident that the strain of the backward pressure of blood must be borne by those portions of the segments which are strengthened by fibrous tissue extending from each nodule to the attached border of each segment. Though the lunulæ are thin and weak, nevertheless, being, so to speak, doubled up against one another, the more they are pressed upon the more closely they fit together.

When the aortic valve offers opposition to the entrance of blood into the aorta, the cardiac affection is called aortic obstruction (stenosis). On the

other hand, when the aortic valve is incompetent, and allows regurgitation of blood to take place into the left ventricle, the cardiac affection is called aortic regurgitation (incompetence).

The **pulmonary valve,** which guards the orifice of the pulmonary artery, is similar to the aortic valve, and the preceding description is, for the most part, applicable to it. The segments of the pulmonary valve are, however, weaker than those of the aortic valve, and the **sinuses of Valsalva** are destitute of any arterial orifices. These sinuses are disposed as *anterior*, *right postero-lateral*, and *left postero-lateral*, respectively.

The function of the pulmonary valve is similar to that of the aortic valve.

Interventricular Septum.—This septum completely separates the right and left ventricles. The external indications of its attachments are the antero-superior and inferior interventricular grooves. It is thick and, for the most part, fleshy. It is thickest in the region of the apex, and becomes thinner towards the base of the ventricles. It bulges into the right ventricle, so as to be convex on that aspect, whilst it recedes from the left ventricle, so as to be concave towards it. The upper or basal part of the septum presents anteriorly a small portion which is destitute of muscular fibres. This portion is thin, and consists of fibrous tissue, covered on either side by endocardium. It is known as the *pars membranacea septi*, and is developed from the lower part of the septum which divides the aortic bulb into the ascending aorta and trunk of the pulmonary artery. It forms part of the aortic vestibule of the left ventricle. In rare cases the interventricular septum is deficient in the region of the pars membranacea, and a communication thus exists between the right and left ventricles.

Topography of the Orifices of the Heart.—The **pulmonary orifice** is situated on a level with the upper margin of the third left costal cartilage at its junction with the sternum. The **aortic orifice,** which is more deeply placed than the pulmonary, is situated behind the left border of the sternum on a level with the lower margin of the third left costal cartilage.

The **tricuspid orifice** lies behind the body of the sternum opposite the fourth intercostal spaces and fourth and fifth costal cartilages. The **mitral orifice,** which is placed very deeply, is situated behind the left border of the sternum on a level with the fourth left costal cartilage.

Cardiac Bloodvessels—Arteries.—The nutrient vessels of the heart are the coronary arteries, right and left, which arise from the root of the ascending aorta. For a description of these vessels, see p. 901.

Veins.—The cardiac veins are as follows : the great or left cardiac or coronary vein ; the coronary sinus ; the posterior cardiac veins ; the middle cardiac vein ; the right or small cardiac or coronary vein ; the anterior cardiac veins ; the oblique vein of Marshall ; and the venæ minimæ cordis or smallest cardiac veins. With the

exception of the last-named cardiac veins (venæ minimæ cordis), all the others are seen upon the exterior of the heart.

The **great** or **left cardiac** or **coronary vein** commences at the apex of the heart, and ascends in the antero-superior interventricular groove alongside of the descending branch of the left coronary artery. In this part of its course it is more properly called the *antero-superior interventricular vein*. It is of large size, and receives tributaries from both ventricles and from the inter-

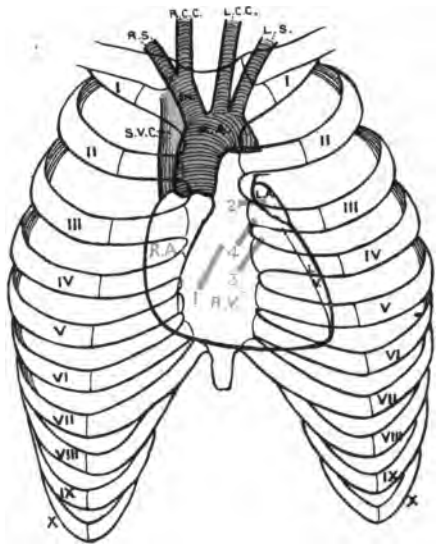


FIG. 393.—DIAGRAM SHOWING THE POSITION OF THE HEART AND ITS VALVULAR ORIFICES IN RELATION TO THE ANTERIOR WALL OF THE THORAX.

R.A. Right Auricle
R.V. Right Ventricle
L.A. Left Auricle
L.V. Left Ventricle
A.A. Arch of Aorta
IN. Innominate Artery
R.S. Right Subclavian Artery
R.C.C. Right Common Carotid Artery
L.C.C. Left Common Carotid Artery
L.S. Left Subclavian Artery
S.V.C. Superior Vena Cava

NUMBERS ON STERNUM.

1. Tricuspid Orifice
2. Pulmonary Orifice
3. Mitral Orifice
4. Aortic Orifice

ventricular septum. On reaching the auriculo-ventricular groove, it enters the left division of that groove, in which it courses along with the transverse branch of the left coronary artery. Having turned round the left margin of the heart, it joins the left extremity of the coronary sinus, with which it is continuous. The name *coronary* is strictly applicable to this vessel only where it lies in the left auriculo-ventricular groove.

The **coronary sinus** (see Fig. 385, p. 917) is the dilated terminal

part of the great cardiac vein. It is about 1 inch in length, and occupies a portion of the posterior part of the left auriculo-ventricular groove. Its left extremity is continuous with the great cardiac vein, and its right extremity opens into the right auricle between the vestigial Eustachian valve and the auriculo-ventricular orifice, the opening being guarded by the Thebesian valve. At the place where the coronary sinus is continuous with the great cardiac vein there is a valve, which is composed of two segments.

The coronary sinus is the persistent terminal part of the *left duct of Cuvier*.

The **posterior cardiac veins** ascend upon the inferior surface of the left ventricle, and open partly into the coronary sinus, and partly into the contiguous portion of the great cardiac vein. One of them is known as the *left marginal vein*.

The **middle cardiac vein** (more properly called the *inferior interventricular vein*), which is of large size, commences at the apex of the heart, and passes along the inferior interventricular groove with the descending branch of the right coronary artery. It receives tributaries from the adjacent surface of the right ventricle and from the interventricular septum, as well as a few from the left ventricle, and it opens into the right extremity of the coronary sinus.

The **right** or **small cardiac** or **coronary vein** occupies the right auriculo-ventricular groove, in company with the right coronary artery, and it opens into the right extremity of the coronary sinus. It is subject to some variation, but it usually receives tributaries from the contiguous parts of the right auricle and right ventricle, including the anterior cardiac veins.

The **anterior cardiac veins** ascend on the front of the right ventricle, and open into the right cardiac vein. One of them is known as the *right marginal vein*.

The **oblique vein of Marshall,** which is a persistent part of the *left duct of Cuvier*, passes downwards and inwards over the posterior aspect of the left auricle, and opens into the left extremity of the coronary sinus, its orifice being destitute of a valve.

Tributaries of the Coronary Sinus.—These are as follows : (1) the great or left cardiac vein ; (2) some of the posterior cardiac veins, others of these veins opening into the great cardiac vein ; (3) the middle cardiac vein ; (4) the right cardiac vein ; and (5) the oblique vein of Marshall. With the exception of the last-named tributary, all the others are provided with valves at their terminal orifices, but elsewhere they are destitute of valves.

The **smallest cardiac veins,** or *venæ minimæ cordis*, also known as the *venæ Thebesii*, are not visible upon the exterior of the heart. They are very minute, and they open into the right auricle, their orifices constituting some of the foramina Thebesii. Similar minute veins are said to open into the left auricle, and also into both ventricles.

Lymphatics. — The lymphatics of the heart are very numerous,

and are present in the muscular substance, as well as beneath the epicardium and endocardium. On the surface of the heart they form a plexus, from which two trunks, right and left, issue. These trunks pass backwards, one on either side of the trunk of the pulmonary artery, to the superior mediastinal glands, and thence to the right lymphatic duct and thoracic duct respectively.

Nerves.—The nerves of the heart are derived from the superficial and deep cardiac plexuses, and, through these, from the pneumogastric and sympathetic nerves. The branches to the auricles are derived partly from the deep cardiac plexus, and partly from the coronary plexuses. They form a gangliated plexus on the surface of each auricle beneath the epicardium, and from this plexus branches proceed to the muscular wall. The branches to the ventricles are derived from the right and left coronary plexuses. These branches lie upon the surface of each ventricle beneath the epicardium, and in the heart of the calf they are readily recognisable as delicate, thread-like streaks. Minute ganglia are met with, at intervals, on these nerves in the region of the base of the ventricles, but none on those nerves which lie over the lower two-thirds of each ventricle. The branches which enter the muscular substance of the ventricular walls form plexuses, but are destitute of ganglia.

Structure of the Heart.—The cardiac wall is composed of muscular tissue, which is known as the **myocardium.** This is intimately covered by the visceral layer of the serous portion of the pericardium, this layer being called the **epicardium,** and the cavities of the heart are lined with a membrane which is known as the **endocardium.**

The **epicardium** resembles a serous membrane in structure, and is covered by endothelium. It is provided with *stomata*, which establish a communication between its lymph-canalicular system and the cavity of the pericardium. Beneath the epicardium there is a variable amount of fat, which is chiefly met with in the auriculo-ventricular and interventricular grooves.

The **endocardium** is a smooth, delicate membrane, destitute of blood-vessels, and covered on its internal surface by endothelium. It consists of a connective-tissue basement membrane, containing elastic fibres, and is continuous, through the arterial and venous orifices, with the *tunica intima* of the vessels. It enters into the formation of the segments of the auriculo-ventricular and semilunar valves.

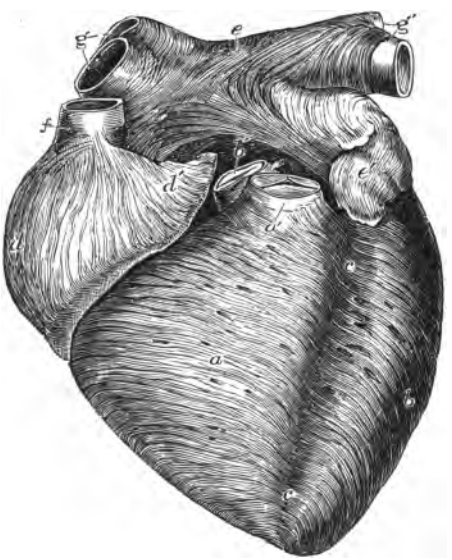
Fibrous Tissue.—The auriculo-ventricular and arterial orifices of the heart are each surrounded by a ring of fibrous tissue, and these rings, in the case of the auricles and ventricles, connect them together. The fibrous tissue of these rings furnishes that which is met with in the segments of the various valves. In the triangular interval between the aortic and the two auriculo-ventricular orifices there is a collection of dense fibrous tissue, of the consistence of fibro-cartilage, which is connected with the fibrous rings just referred to. When a heart is boiled, the fibrous tissue is dissolved, and the auricular portion can be separated from the ventricular portion.

Myocardium.—The muscular tissue of the auricles is quite distinct from that of the ventricles, the fibrous rings at the auriculo-ventricular orifices intervening between the two, and serving to connect them.

Auricles.—The muscular fasciculi of the auricles are arranged in a superficial set, common to both auricles, and a deep set, confined to each auricle. The *superficial fasciculi* are disposed transversely, and some of them enter the interauricular septum. They are best marked in front. The *deep fasciculi* are arranged in two sets, looped and circular. The *looped fasciculi*

arch vertically over the auricle, their extremities being attached to the ring of fibrous tissue which surrounds the auriculo-ventricular orifice. The *circular fasciculi* are present in the auricular appendix, around the venous orifices, and around the fossa ovalis. The walls of the auricles, though muscular, are thin.

Ventricles.—The muscular fasciculi of the ventricles are, as stated, quite distinct from those of the auricles, and are disposed in a very complicated manner. They spring, for the most part, from the rings of fibrous tissue which surround the auriculo-ventricular orifices. The *superficial fasciculi* descend obliquely towards the apex, where they are disposed in a twisted or whorled manner, after which they pass on to the inner surface of the left ventricle. Some of them become continuous with the musculi papillares of that ventricle, whilst others ascend as a vertical layer on the inner surface of the ventricle to be attached to the left auriculo-ventricular fibrous ring. The superficial fasciculi are common to both ventricles.



This figure is planned after one of Luschka's, but its details were chiefly taken from an original preparation. The aorta, *b'*, and pulmonary artery, *a'*, have been cut short close to the semilunar valves, so as to show the anterior fibres of the auricles. *a*, superficial layer of the fibres of the right ventricle; *b*, that of the left; *c*, *c*, anterior interventricular groove; *d*, right auricle; *d'*, its appendix, both showing chiefly perpendicular fibres; *e*, upper part of the left auricle; between *e* and *b'*, the transverse fibres which behind the aorta pass across both auricles; *e'*, appendix of left auricle; *f*, superior vena cava, around which, near the auricle, circular fibres are seen; *g*, *g'*, right and left pulmonary veins with circular bands of fibres surrounding them.

FIG. 394.—ANTERIOR VIEW OF HEART OF A YOUNG SUBJECT DISSECTED AFTER LONG BOILING, TO SHOW THE SUPERFICIAL MUSCULAR FIBRES (ALLEN THOMSON). ⅔. (FROM QUAIN'S 'ANATOMY.')

The remaining fasciculi are very numerous, and must be described separately for each ventricle. The principal fasciculi of the *left* ventricle spring from the left auriculo-ventricular fibrous ring, and they pass more or less obliquely towards the apex. In their course they turn inwards, and enter the front part of the interventricular septum inferiorly. Some of them now pass upwards to the base of the ventricle to be attached to the collection of dense fibrous tissue, of the consistence of fibro-cartilage, already described; others pass across to the postero-inferior wall of the right ventricle, where they partly end in a musculus papillaris, and partly pass to be attached to the right auriculo-ventricular fibrous ring; whilst a third set pass to the postero-inferior wall of the left ventricle, where they become circular in direction. The principal fasciculi of the *right* ventricle are, like the superficial fasciculi, continuous with those of the left ventricle, and they spring from the fibrous rings around the auriculo-ventricular and pulmonary orifices.

* **Fibres of Purkinje.**—These fibres are situated between the endocardium and the cardiac muscular tissue. They consist of elongated cells, united at their ends so as to form chains. The central part of each cell contains granular protoplasm, within which there are two nuclei; and the peripheral part presents transverse striations. These cells are probably vestiges of an early condition of cardiac muscular fibres.

Auriculo-Ventricular Bundle.—This bundle constitutes the *only* auriculo-ventricular muscular connection, and functionally it is of a conducting nature. It may be described in three sections—auricular (atrial), nodal, and ventricular.

The *auricular section* consists of fibres which are derived from (1) the circular fibres of the right auricle, just above the base of the *septal cusp* of the tricuspid valve, and (2) the muscular tissue of the interauricular septum at a point situated at the lower and anterior part of the septum on its right side, just above the anterior end of the base of the septal cusp of the tricuspid valve. These auricular fibres (circular and septal) enter the *central fibrous body* of the heart, which is situated between the aortic and the two auriculo-ventricular orifices.

The *nodal section* is situated within the central fibrous body. It is a small *knot*, consisting of an intricate network of muscular fibres, intermingled with, and embedded in, fibrous tissue.

The *ventricular section* emerges from the nodal section as a *single bundle*, which represents the **main stem** of the auriculo-ventricular bundle. This stem passes forwards along the upper margin of the *muscular portion* of the nterventricular septum, lying immediately below the *pars membranacea septi*, and beneath the anterior part of the base of the septal cusp of the tricuspid valve. In this situation the main stem breaks up into two divisions —right and left. Each of these divisions enters the septal wall of the corresponding ventricle, and divides into branches which ramify beneath the endocardium, where they form part of the system of Purkinje's fibres. Ultimately the terminal ramifications blend with the muscular fibres of the ventricles and *musculi papillares*.

The fibres of the auriculo-ventricular bundle are pale, and are furnished with nerve-fibres and ganglia. The clinical significance of the bundle has reference to Stokes-Adams disease or **heart-block.** (Kent, His Junior, Tawara, and Keith and Flack.)

[*To face p.* 933.

Those on the postero-inferior surface of the right ventricle pass into the interventricular septum, and, having traversed it obliquely forwards and upwards, they issue from it, and become continuous with the deep fibres of the left ventricle. Those on the antero-superior surface of the right ventricle also pass into the interventricular septum, and having traversed it obliquely backwards and downwards, they pass on to the postero-inferior wall of the left ventricle. Those from the inferior aspect of the right ventricle enter the lower part of the interventricular septum, and ascend in the septum to the collection of dense fibrous tissue of the consistence of fibro-cartilage at the base. Although the ventricular muscular fasciculi are disposed for the most part obliquely, there are some circular fasciculi, but these are confined to the thickest part of each ventricular wall.

FIG. 395. — THE SUPERFICIAL MUSCULAR FIBRES OF THE HEART IN THE REGION OF THE APEX (C. GEGENBAUR).

The whorled arrangement is well shown.

***Structure of the Cardiac Valves.**—Each segment of the tricuspid and mitral valves consists of two layers of endocardium, enclosing between them fibrous tissue which is derived from the fibrous ring around the corresponding auriculo-ventricular orifice. Each segment of the aortic and pulmonary valves also consists of two layers of endocardium, enclosing between them fibrous tissue which is derived from the fibrous ring around the corresponding arterial orifice. The segments of all the valves are destitute of bloodvessels.

FIG. 396.—CARDIAC MUSCULAR FIBRES, SHOWING THEIR TRANSVERSE STRIÆ, DIVISIONS, JUNCTIONS, AND POSITION OF THE NUCLEI.

Minute Structure of the Myocardium.—Cardiac muscle is composed of transversely striated fibres, but these differ so much from ordinary striated voluntary muscular fibres as to require a special description. They possess no sarcolemma; they branch freely, and adjacent branches unite, so that an intricate network is formed by them; and the transverse striæ are fainter and less regular than those of voluntary muscle. Each fibre and its branches are broken up into a series of short quadrangular *muscle-corpuscles*, arranged in rows or chains, and separated from one another by cross-marks. Each muscle-corpuscle contains one nucleus, which occupies *the centre* of the corpuscle and the corpuscle presents longitudinal striæ as well as transverse. A cardiac muscular fibre, as well as its branches, is therefore a chain of muscle-corpuscles, each of which has a nucleus at its centre, and there is an absence of sarcolemma.

Weight of the Heart.—The average weight of the heart of the adult male is 10½ ounces, and of the adult female 8½ ounces.

Size.—The size of a normal heart has been compared to the closed hand of the individual person.

Development of the Heart.—The primitive heart makes its appearance as *two tubes*, one on either side, in the splanchnic mesoblast in the region of the head. When this mesoblast turns round, on either side, to form the fore-gut, these two tubes become approximated, and they unite along the median line to form a *single longitudinal tube*. This tube represents the primitive heart, and is situated on the ventral aspect of the fore-gut. Its anterior extremity divides into

two branches—the primitive aortæ, which pass backwards on either side of the fore-gut, forming the first aortic arches, and then on either side of the notochord. The posterior extremity of the single tube divides into two vessels, which diverge and become the vitelline or omphalo-mesenteric veins for the return of blood from the vascular area on the yolk-sac. The tube (primitive heart) soon describes two bends, which impart to it the shape of a capital S, and constrictions make their appearance so as to divide it into the following four parts: (1) the sinus venosus; (2) the auricular portion; (3) the ventricular portion; and (4) the aortic bulb, or bulbus arteriosus.

The **sinus venosus** consists of a central part and two lateral enlargements or cornua, one on either side. Into each lateral cornu there open (1) the vitelline or omphalo-mesenteric vein, (2) the umbilical vein, and (3) the primitive superior vena cava, or duct of Cuvier. The communication between the sinus venosus and the auricular portion soon becomes small, and assumes a position between the right lateral cornu of the sinus and the right half of the auricular portion, where it is guarded by a right and left valve. The right lateral cornu undergoes enlargement, and the left lateral cornu becomes prolonged into the left duct of Cuvier. At this stage, in which the sinus venosus has a large right lateral cornu and a small left lateral cornu, the sinus is known as the *saccus reuniens of His*, and it lies transversely below and behind the auricular portion of the primitive heart. At a later stage all the

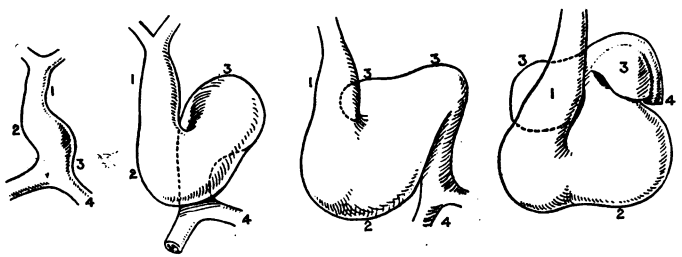


FIG. 397.—SCHEME SHOWING FOUR SUCCESSIVE STAGES IN THE DEVELOPMENT OF THE HEART (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Arterial Bulb. 2. Ventricle. 3. Auricle.
4. Veins opening into the Sinus Venosus.

veins, except the left duct of Cuvier, open into the right lateral cornu; the communication between the right lateral cornu and the right half of the auricular portion becomes enlarged; and the right lateral cornu becomes absorbed into the right half of the auricular portion. The left valve disappears, and the right valve gives rise to the Eustachian and Thebesian valves. The transverse part of the sinus venosus, through means of the left lateral cornu, is continuous with the left duct of Cuvier, which latter persists as the *coronary sinus*.

The **ventricular portion** of the heart is connected at its left extremity with the auricular portion, and at its right extremity it turns upwards and is continued into the aortic bulb. Its interior becomes divided into right and left ventricles by means of a muscular septum which is gradually developed in a direction upwards and backwards. This septum remains incomplete superiorly for some time, so that the two ventricles are here in communication with each other. Subsequently, however, the septum is completed superiorly by (1) an extension from the partition which divides the aortic bulb into the ascending aorta and the trunk of the pulmonary artery, and (2) an extension from the endocardial growths, which by their fusion divide the single orifice between the auricle and ventricle into right and left auriculo-ventricular orifices. The upper portion of the septum, formed in this manner, represents the *pars membranacea septi* of the adult heart.

The opening between the auricle and ventricle, which has gradually shifted from the left extremity of the ventricular portion to its upper and back part, becomes elongated into the *auricular canal*. The opening of this canal into the ventricle ultimately becomes shifted till it lies over the position of the ventricular septum. The margins of the opening then become thickened by endocardial growths, and these come together at the centre of the orifice and fuse. In this manner the single orifice becomes divided into right and left auriculo-ventricular orifices. From the fusion of the endocardial growths an extension grows downwards, as stated, to meet the upwardly-rising ventricular septum.

The division of the auricular portion into two auricles, right and left, is effected by means of a septum, called the **septum primum,** which grows gradually downwards and forwards from the upper and back part of the cavity. This septum eventually joins the fused endocardial growths which divide the single auricular orifice into two, right and left, and so the communication between the two auricles is closed. Prior to this closure, however, the septum primum at its upper and back part becomes disconnected with the auricular wall ; an opening, called the *foramen ovale*, is formed ; and the septum primum constitutes what is called the *valve of the foramen ovale*. Another septum, known as the **septum secundum,** grows from the upper and back part of the auricle, at a point to the right of the original attachment of the septum primum, in a direction downwards and forwards over the foramen ovale. The septum secundum gradually closes the foramen ovale, and gives rise to the *annulus ovalis*, or *limbus Vieussenii*, and the portion of the auricular septum above it.

The **aortic bulb** becomes divided into the ascending aorta and the trunk of the pulmonary artery. For this purpose the endocardial lining becomes thickened, and forms two longitudinal folds, which are placed opposite each other. These folds grow towards the centre of the aortic bulb, where they meet and fuse to form a septum, and in this manner the cavity of the bulb is divided into the two vascular tubes just mentioned. In the lower part of the aortic bulb the two folds are disposed *laterally*, right and left, which accounts for the pulmonary artery and the ascending aorta being at first placed anteriorly and posteriorly respectively. In the upper part of the aortic bulb, however, the two folds are disposed one *in front*, and the other *behind;* hence the lateral positions of the ascending aorta and the trunk of the pulmonary artery a little above their roots. Two grooves make their appearance on the exterior of the aortic bulb, which correspond in position with the longitudinal folds in the interior, and, as these grooves deepen, the bulb becomes separated into two distinct vessels.

The septum of the aortic bulb, as stated, grows downwards to join the interventricular septum, and, when the union is effected, the division of the ventricular portion of the heart into two ventricles is complete. Thereafter the right ventricle communicates wtih the pulmonary artery, and the left ventricle with the ascending aorta.

Peculiarities of the Fœtal Circulation. — The structures peculiar to the fœtus in connection with the circulation of the blood are as follows :

1. Foramen ovale.
2. Eustachian valve.
3. Ductus arteriosus.
4. Hypogastric and umbilical arteries.
5. Umbilical vein.
6. Ductus venosus.

The **foramen ovale** is an oval opening in the interauricular septum. Up to the fourth month of intra-uterine life it is quite free, but after that period the *valve of the foramen ovale* gradually extends upwards on the left side of, and beyond, the annulus ovalis, and acts as a valve during the latter months of fœtal life. The blood can then

only flow from the right auricle into the left, its return being prevented by this valve.

The **Eustachian valve** is of large size during fœtal life, and is associated with the orifice of the inferior vena cava at the postero-inferior angle of the right auricle. It is a crescentic fold of the endocardium, which extends between the anterior margin of the orifice of the inferior vena cava and the anterior horn of the annulus ovalis. Its situation is such as to direct the blood entering the right auricle by the inferior vena cava to the foramen ovale.

The **ductus arteriosus** connects the trunk of the pulmonary artery to the arch of the aorta at a point immediately beyond the origin of the left subclavian artery, and it conveys the most of the blood from the right ventricle to the descending thoracic aorta.

The **hypogastric arteries,** right and left, are prolonged from the common iliac arteries to the umbilicus, through which they leave the body of the fœtus, and, under the name of the **umbilical arteries,** they pass along the umbilical cord to be distributed to the fœtal part of the placenta. They convey the impure blood of the fœtus to the placenta.

The **umbilical vein** extends from the fœtal part of the placenta through the umbilicus to the inferior surface of the liver, where it traverses the umbilical fissure, and gives off right and left branches to the right and left lobes, which join the branches of the vena portæ. After parting with its right and left branches the umbilical vein is prolonged, under the name of the **ductus venosus,** to the inferior vena cava, which it joins at the caval fossa of the liver. The umbilical vein conveys pure blood from the placenta into the body of the fœtus.

Fœtal Circulation.—The right auricle receives blood from the superior and inferior venæ cavæ, and from the coronary sinus. The superior vena cava returns the venous blood from the head and neck, the upper limbs, and the thoracic portion of the trunk; and the inferior vena cava returns the blood from the lower limbs, the abdominal portion of the trunk, and the placenta. The placental blood is pure, and reaches the inferior vena cava in two ways: (1) a large quantity of it is conveyed directly into the inferior vena cava by the ductus venosus; and (2) some of it circulates through the liver in the branches of the vena portæ, and is thereafter conveyed to the inferior vena cava by the hepatic veins. The blood entering the right auricle by the inferior vena cava is necessarily of a mixed nature, being partly placental and partly venous.

The impure blood which enters the right auricle by the superior vena cava, having received a small quantity of the mixed blood which enters by the inferior vena cava, passes through the right auriculo-ventricular orifice into the right ventricle, and from thence is driven into the trunk of the pulmonary artery. A small quantity of it is conveyed to the lungs by the right and left pulmonary arteries, which at this period are of small size, and it is

returned from the lungs to the left auricle by the pulmonary veins. By far the greater part of the right ventricular blood, however, enters the ductus arteriosus, and is conveyed by it to the aorta immediately *beyond* the origin of the left subclavian artery. None of this blood, therefore, enters the three great vessels which spring from the arch of the aorta. The whole of it descends in the descending thoracic and abdominal portions of the aorta, and has a

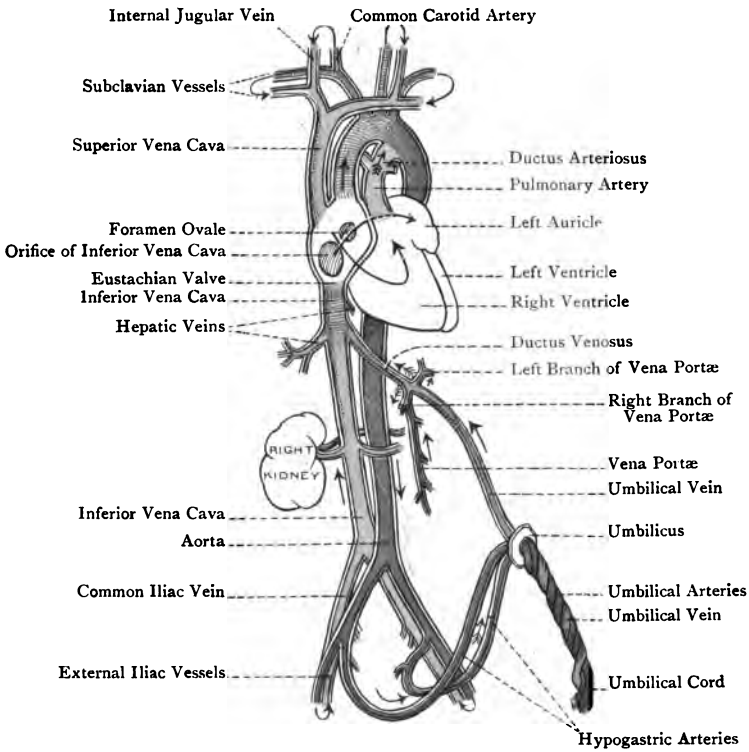


FIG. 398.—DIAGRAM OF THE ORGANS OF CIRCULATION IN THE FŒTUS

(The arrows indicate the course of the Circulation).

twofold destination. Part of it is distributed to the abdominal and pelvic viscera, and the lower limbs, whence it is returned by the vena portæ and inferior vena cava; but the greater part of it is conveyed out of the body of the fœtus to the placenta by means of the hypogastric and umbilical arteries. Having been purified in the placenta, it is returned thence by the umbilical vein into the body of the fœtus. This placental blood, as stated, reaches the inferior vena cava in two ways, partly directly by means of the

ductus venosus, and partly indirectly by means of the hepatic veins after having circulated through the liver.

A small quantity of the mixed blood which enters the right auricle by the inferior vena cava mingles with the venous blood which enters that cavity by the superior vena cava; but by far the greater part of it is directed by the Eustachian valve to the foramen ovale, through which it passes into the left ventricle. Here it receives the blood which has been returned from the lungs by the pulmonary veins, and then it passes through the left auriculo-ventricular orifice into the left ventricle. From the left ventricle it is driven into the aorta, and the greater part of it passes into the innominate, left common carotid, and left subclavian arteries to be distributed to the brain, head and neck, and upper limbs, as well as to the substance of the heart by the coronary arteries. A small quantity, however, of this mixed blood passes into the descending thoracic aorta, and mixes with the venous blood entering by the ductus arteriosus. The blood is returned to the right auricle of the heart from the brain, head and neck, and upper limbs, by the superior vena cava, and from the substance of the heart by the coronary sinus.

Changes at Birth.—At birth respiration is established, and the lungs perform their respiratory function; the right and left pulmonary arteries undergo rapid enlargement; and the placental circulation is entirely arrested. The **hypogastric arteries** become obliterated and transformed into fibrous cords, except at their roots, where they persist as the *internal iliac arteries*. The **umbilical vein** becomes obliterated, and is now known as the *round ligament of the liver*. The **ductus venosus** becomes transformed into a fibrous cord, called the *ligamentum ductûs venosi*, which occupies the venosal fissure of the liver. The **foramen ovale** is closed by the *valve of the foramen ovale* becoming adherent to the margin of the *annulus ovalis* or *limbus Vieussenii* on its left side. In some cases, however, this union is incomplete, and a minute opening persists, through which a small probe may be passed. In very rare cases a fairly large opening may remain, as in the condition known as *morbus cæruleus*. As viewed from the interior of the left auricle, the upper crescentic border of the valve of the foramen ovale is visible upon the interauricular septum, and above this border there is a slight depression. The **ductus arteriosus** becomes obliterated, and persists as a fibrous cord, called the *ligamentum ductûs arteriosi*, which passes from the root of the left pulmonary artery to the arch of the aorta immediately *beyond* the origin of the left subclavian artery.

The closure of all the peculiar structures associated with the fœtal circulation is usually complete from the eighth to the tenth day after birth.

Development of the Principal Arteries.—In the embryo the aortic bulb or bulbus arteriosus divides into two vessels, called the **primitive ventral aortæ**, which pass forwards on the ventral aspect of the fore-gut. From each of

these vessels two arterial arches are given off, and from the aortic bulb four arches are given off, on either side, which arise by a common stem. Subsequently two of these four arches arise directly from each ventral aorta, and two maintain their connection with the aortic bulb. There are thus **six arterial arches** on each side, four of which spring from the corresponding ventral aorta, and two from the aortic bulb. They are named first, second, third, fourth, fifth, and sixth, in this order from before backwards, and they enter the corresponding visceral arches. The arterial arches are continued into the **two primitive dorsal aortæ,** each dorsal aorta being continuous with the ventral aorta through means of the first arterial arch. The primitive dorsal aortæ pass backwards on either side of the notochord, and they terminate at first in the two allantoic arteries, which convey the blood to the allantois. Subsequently the dorsal aortæ unite, about the level of the fourth thoracic vertebra, to form one vessel—the dorsal aorta.

The **arterial arches,** as stated, are first, second, third, fourth, fifth, and sixth, from before backwards. As development proceeds, important changes take place during the formation of the principal vessels. The first, second, and fifth arches on each side disappear, and so also does the sixth right arch. The part of the left dorsal aorta between the third and fourth left arches disappears, and so also does the part of the right dorsal aorta which extends from the third right arch to the place of junction of the two dorsal aortæ.

The sixth left arch at its commencement gives rise to the terminal portion of the trunk of the pulmonary artery. It then furnishes the right and left pulmonary arteries, and beyond this point it gives rise to the ductus arteriosus, which joins the left dorsal aorta. The root of the left ventral aorta forms the part of the arch of the aorta between the innominate and left common carotid arteries. The fourth left arch forms the part of the arch of the aorta between the left common carotid artery and the point of entrance of the ductus arteriosus. The part of the left dorsal aorta between the fourth left arch and the place of junction of the two dorsal aortæ forms the commencement of the descending aorta. The root of the right ventral aorta gives rise to the innominate artery. The fourth right arch forms the *first* part of the right subclavian artery as far as the origin of the internal mammary artery. The part of each ventral aorta between the third and fourth arches forms the corresponding common carotid artery. The third arch and the part of the dorsal aorta above it persist as the *internal* carotid artery, whilst the part of the ventral aorta above the third arch forms the *external* carotid artery.

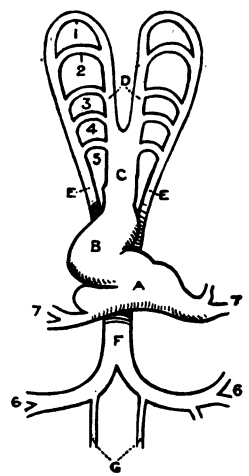


FIG. 399.—DIAGRAM OF THE HEART AND PRIMITIVE VESSELS OF THE EMBRYO CHICK, AS SEEN FROM BELOW AND ENLARGED (AFTER ALLEN THOMSON, IN QUAIN'S 'EMBRYOLOGY').

A, Auricle; B, Ventricle; C, Bulbus Arteriosus; D, Primitive Ventral Aortæ; E, E, Primitive Dorsal Aortæ; F, Single Dorsal Aorta; G, Continuations of the Dorsal Aortæ beyond the origins of the Vitelline Arteries; 1 to 5, Aortic Arches; 6, 6, Vitelline Arteries; 7, 7, Vitelline Veins.

In the foregoing statement of the development of the principal arteries the left subclavian has been left out of account, because it is developed from a segmental artery.

Summary—Ventral Aortæ—*Right Ventral Aorta.*—The root, that is, the part as high as the fourth right arch, forms the innominate artery; the part between the fourth and third arches forms the right common carotid

artery; and the part above the third arch forms the right external carotid artery. *Left Ventral Aorta.*—The root, that is, the part as high as the fourth left arch, forms the part of the arch of the aorta between the innominate and left common carotid arteries; and the part above the fourth left arch acts as on the right side.

Dorsal Aortæ—*Right Dorsal Aorta.*—The part between the third right arch and the place of junction of the two dorsal aortæ disappears; the part above the third arch persists as part of the right internal carotid artery. *Left Dorsal Aorta.*—The part between the third and fourth left arches disappears; the part above the third arch persists as part of the left internal carotid artery. The part between the fourth arch and the place of junction of the two dorsal aortæ forms the commencement of the descending aorta.

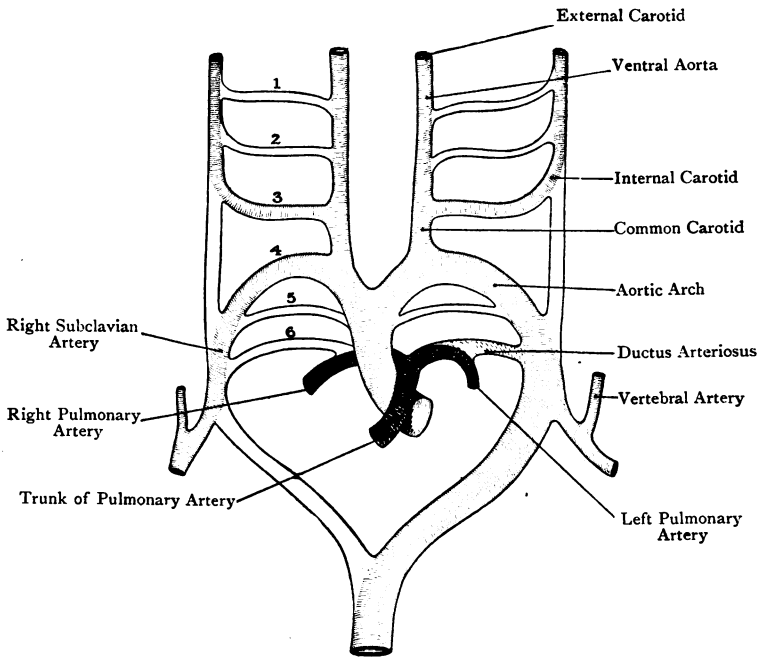


FIG. 400.—SCHEME OF THE AORTIC ARCHES AND THEIR DESTINATION (MODIFIED FROM KOLLMANN) (FROM GRAY'S 'ANATOMY').

Arterial Arches.—The first, second, and fifth arches, on each side, and the sixth right arch disappear. The sixth left arch forms (1) a small portion of the trunk of the pulmonary artery at its termination, (2) the right and left pulmonary arteries, and (3) the ductus arteriosus. The fourth right arch forms the first part of the right subclavian artery as far as the origin of the internal mammary artery. The fourth left arch forms the part of the arch of the aorta between the left common carotid artery and the point of entrance of the ductus arteriosus. The third arch on each side persists as part of the corresponding internal carotid artery.

Summary of the Permanent Aorta.—The ascending aorta is developed from the arterial bulb, in conjunction with the greater part of the trunk of the pulmonary artery. The part of the arch of the aorta between the innominate

and left common carotid arteries is developed from the root of the left ventral aorta, and the part of the arch between the left common carotid artery and the place of entrance of the ductus arteriosus is developed from the fourth left arterial arch. The descending aorta is formed superiorly by a portion of the left dorsal aorta, but for the most part by the fusion of the right and left dorsal aortæ.

According to some authorities, there are only five arterial arches on either side. To adapt this view to the foregoing description, the fifth arch of these authorities is to be regarded as representing the sixth arch just described.

Development of the Veins.—The **primitive veins** are (1) the two primitive jugular veins, right and left, which return the blood from the cranial cavity of the embryo; (2) the two cardinal veins, right and left, which return the blood from the walls of the trunk and the Wolffian bodies; (3) the two vitelline or omphalo-mesenteric veins, right and left, which return the blood from the vascular area on the yolk-sac; and (4) the umbilical veins, which at first are two in number, right and left, and return the blood from the placenta.

Primitive Jugular Veins.—The primitive jugular vein of each side returns the blood from the cranial cavity, and for the most part it gives rise to the *external* jugular vein. Near its lower extremity it is joined at a later period by the internal jugular and subclavian veins. The primitive jugular vein joins the cardinal vein, which ascends from the trunk, and so the **duct of Cuvier** of that side is formed. The ducts of Cuvier, right and left, represent the primitive right and left superior venæ cavæ, and they open into the sinus venosus of the embryonic heart, one on either side. At first they occupy a transverse position, the heart at this period being situated in the neck. As, however, the heart descends into the thorax, each duct of Cuvier passes downwards in line with the corresponding primitive jugular vein. A cross communicating branch, called the **transverse jugular vein,** is now formed, which passes obliquely between the lower ends of the primitive jugular veins, in each case a little below the point where the subclavian and internal jugular veins join it, but lower on the right side than on the left. The greater part of the *left* innominate vein is developed from this transverse jugular vein, whilst the *right* innominate vein is formed from the short portion of the right primitive jugular vein which intervenes between the point where it receives the right subclavian and internal jugular veins and the point where it is joined by the transverse jugular vein. The portion of the right primitive jugular vein immediately below the point where it is joined by the transverse jugular vein forms the *upper* part of the permanent superior vena cava, that is, the part above the point where the right azygos vein opens into it. The *lower* part of the superior vena cava is developed from the *right* duct of Cuvier. The portion of the left primitive jugular vein between the point where it receives the left subclavian and internal jugular veins and the commencement of the transverse jugular vein forms a small part of the left innominate vein; and the portion below and adjacent to the commencement of the transverse jugular vein forms the upper part of the left superior intercostal vein, thus accounting for the ending of that vein in the left innominate vein. The *left* duct of Cuvier becomes obliterated, but the following traces of it persist in the adult: (1) the coronary sinus, (2) the oblique vein of Marshall, and (3) a delicate fibrous cord, contained within a small triangular fold of the serous portion of the pericardium in front of the root of the left lung, known as the vestigial fold of Marshall.

It is right to state that the primitive jugular vein of each side is regarded by some authorities as forming the permanent *internal* jugular vein, and not the external jugular, this latter being of later development.

Cardinal Veins.—These, as stated, are two in number, right and left, and they return the blood from the walls of the trunk and the Wolffian bodies. The *lower part* of each vein receives the sciatic vein, which is the primitive vein of the lower limb, and this lower part of the cardinal vein persists as the *internal* iliac vein. A little above this point it receives, at a later period, the external iliac vein. A communicating vessel, called the **transverse iliac**

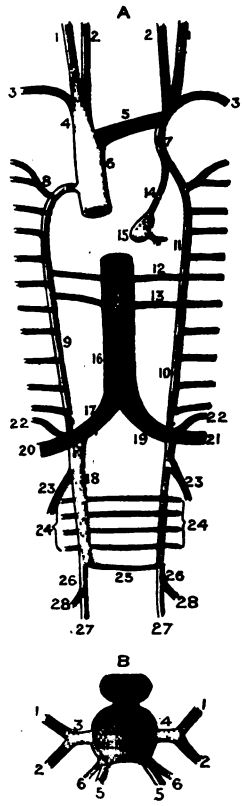


FIG. 401.

A, SCHEME OF THE DEVELOPMENT OF THE PRINCIPAL VEINS. B, SCHEME OF THE PRIMITIVE VEINS WHICH OPEN INTO THE PRIMITIVE HEART.

A

1. External Jugular Vein (Primitive Jugular)
2. Internal Jugular Vein
3. Subclavian Vein
4. Right Innominate Vein
5. Left Innominate Vein
6. Superior Vena Cava
7. Left Superior Intercostal Vein
8. Right Superior Intercostal Vein
9. Right Azygos Vein
10. Lower Left Azygos Vein
11. Upper Left Azygos Vein
12, 13. Transverse Azygos Veins
14. Left Duct of Cuvier (Remains of)
15. Coronary Sinus
16. Inferior Vena Cava
17, 18. Inferior Vena Cava
19. Mesial Part of Left Renal Vein
20. Right Renal Vein
21. Lateral Part of Left Renal Vein
22. Suprarenal Vein
23. Spermatic Vein (Ovarian Vein)
24. Lumbar Veins
25. Transverse Iliac Vein
26. Common Iliac Vein
27. Internal Iliac Vein
28. External Iliac Vein

B

1, 1. Primitive Jugular Veins
2, 2. Cardinal Veins
3. Right Duct of Cuvier
4. Left Duct of Cuvier
5, 5. Vitelline Veins
6, 6. Umbilical Veins

vein, is developed, which extends obliquely from the left cardinal vein a little above the point where it receives the external iliac vein to the right cardinal vein, joining it at a higher level. In its subsequent course each cardinal vein receives veins from the Wolffian body and the walls of the trunk, and in the thoracic region the veins become connected by two transverse branches, upper and lower. Finally, each cardinal vein joins the corresponding primitive jugular vein to form the duct of Cuvier. After the development of the kidney, the renal vein is a tributary of the corresponding cardinal vein. The lower part of the cardinal vein forms, as stated, the internal iliac vein. The transverse iliac vein forms the greater part of the *left* common iliac vein, the first portion of that vessel being developed from that part of the left cardinal vein which intervenes between the termination of the left external iliac vein and the commencement of the transverse iliac vein. The portion of the right cardinal vein which intervenes between the termination of the right external iliac vein and the right extremity of the transverse iliac vein forms the *right* common iliac vein. The portion of the left cardinal vein between the transverse iliac vein and a point a little below the left renal vein becomes obliterated. The portion of it immediately below the left renal vein, which portion receives the left spermatic vein, persists and forms the upper part of the left spermatic vein, thus accounting for the mode of termination of that vein in the adult. The left cardinal vein may again become obliterated for a short distance above the left renal vein, and thereafter its upper or thoracic portion persists as the lower left azygos vein, the upper left azygos vein, and the lower part of the left superior intercostal vein. The portion of the left cardinal vein between the lower and upper left azygos veins, and also the portion between the upper left azygos vein and the left superior intercostal vein, may, or may not, undergo obliteration. The portion of the right cardinal vein between the right extremity of the transverse iliac vein and the right renal vein persists as the *lower part* of the inferior vena cava, and it receives superiorly the *right* spermatic vein, which accounts for the mode of termination of that vein in the adult. The right cardinal vein may become obliterated for a short distance above the right renal vein, and thereafter its upper thoracic portion persists as the right azygos vein, which receives the right superior intercostal vein. The lower transverse communicating branch between the cardinal veins in the thorax persists as the lower transverse azygos vein, and the upper transverse branch persists as the upper transverse azygos vein.

Vitelline or **Omphalo-mesenteric Veins.**—These, as stated, are two in number, right and left. They return the blood from the vascular area on the yolk-sac, and enter the cœlom or body-cavity of the embryo along the vitelline duct. They are the first veins to become developed, and they give rise to the portal and hepatic veins. Within the body-cavity the vitelline veins open into the sinus venosus of the primitive heart. The sinus venosus also receives, near the vitelline veins, the two umbilical veins, right and left, which return the blood from the placenta. In addition, it receives the right and left ducts of Cuvier, or primitive superior venæ cavæ, which open into it one on either side. The vitelline veins, after entering the body-cavity, arrange themselves one on either side of the primitive duodenum. In this situation three transverse connections are formed between them, two being in front of the gut, upper and lower, and one behind it. In this manner the duodenum is embraced by two venous rings, placed one above the other. The lower connection between the vitelline veins amounts to a fusion of the two vessels for a short distance, and this united portion, which receives veins from the intestinal tube and stomach, forms the *lower* part of the vena portæ. The *upper* part of that vessel is formed by the *left* half of the lower venous ring and the *right* half of the upper one, the other halves of these rings undergoing obliteration. The vitelline veins having ceased to be connected with the sinus venosus, the portions of them above the upper duodenal ring break up into a network of vessels within the liver, which is now being developed, the vessels in the centre of the network being of a capillary nature. The veins which carry the blood to these capillaries are called the *venæ advehentes*,

and they represent the right and left divisions of the vena portæ. The vessels which pass from the capillaries to the sinus venosus are called the *venæ revehentes*, and they form the hepatic veins.

Umbilical Veins.—These veins persist as two vessels, right and left, for some time, and, as stated, they open into the sinus venosus. Subsequently they cease to be connected with that sinus, and a communication becomes established between the left umbilical vein and the upper venous duodenal ring. The right umbilical vein becomes obliterated, and the left vein undergoes enlargement. At first its blood circulates entirely through the capillaries of the liver. At a later stage, however, a branch is formed which extends from the upper venous duodenal ring to the right hepatic vein near its entrance into the sinus venosus. This branch represents the **ductus venosus,** and it conveys placental blood to the sinus venosus without any of this blood having to circulate through the liver. Subsequently the left hepatic vein, having

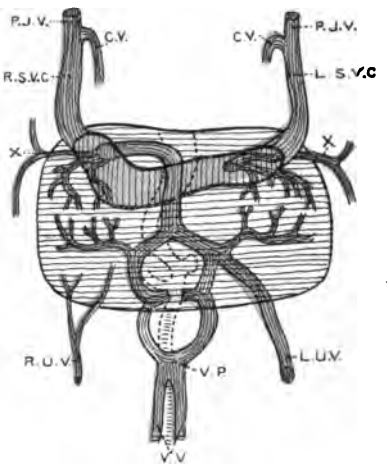


FIG. 402.—THE VENOUS TRUNKS OF THE HUMAN EMBRYO (HIS).

P.J.V. Primitive Jugular Vein
C.V. Cardinal Vein
R.S.V.C. Right Superior Vena Cava
L.S.V.C. Left Superior Vena Cava
X.X. Upper separated portions of Umbilical Veins
R.U.V. Right Umbilical Vein
L.U.V. Left Umbilical Vein
V.P. Vena Portæ
V.V. Vitelline Veins

ceased to be connected directly with the sinus venosus, forms a communication with the upper end of the ductus venosus, which end is connected with the inferior vena cava.

Development of the Inferior Vena Cava.—This vessel makes its appearance later than the preceding veins. It commences at the cardiac end of the ductus venosus, and from this point it is developed in a downward direction in front of the aorta. Having reached the interval between the kidneys, it divides into two branches, right and left, each of which joins the corresponding cardinal vein on a level with the renal vein. The portion of the cardinal vein immediately above the junction may disappear, or it may persist, and so establish a connection between the azgyos vein and the inferior vena cava, or the renal vein. The primitive inferior vena cava and its *right division* persist as the *upper part* of the permanent inferior vena cava. The portion of the right cardinal vein between the right renal vein above and the point of entrance of the transverse iliac vein below persists, and forms the *lower*

part of the permanent inferior vena cava, which is thus usually placed on the right side of the vertebral column. The *left division* of the primitive inferior vena cava persists, and forms the *mesial part of* the left renal vein. The explanation of the occasional presence of a permanent inferior vena cava on the left side of the vertebral column, instead of on the right side, will be readily understood.

Trachea in the Thorax.—The thoracic portion of the trachea extends from the level of the upper border of the manubrium sterni to the level of the intervertebral disc between the bodies of the fourth and fifth thoracic vertebræ, where it divides into the two bronchi, right and left. It occupies a median position in the superior mediastinum, and its length is about 2½ inches. As in the neck, it is cylindrical and firm in front and at the sides, but posteriorly it is flattened and membranous, where it rests upon the œsophagus.

Relations—*Anterior.*—The manubrium sterni, and the origins of the sterno-hyoid and sterno-thyroid muscles; the remains of the thymus body; the origins of the innominate and left common carotid arteries, and the left innominate vein; and the arch of the aorta, which lies upon it immediately above its bifurcation into the two bronchi, with the intervention of the deep cardiac plexus of nerves. *Posterior.*—The œsophagus, which inclines partially to the left of the trachea. *Right.*—The right pneumogastric nerve; the innominate artery, after it has left the front of the trachea; and the right pleural sac. *Left.*—The arch of the aorta and the left common carotid artery, after these have left the front of the trachea; the left subclavian artery; and the left recurrent laryngeal nerve.

Bronchi.—The bronchi, right and left, commence at the bifurcation of the trachea, and each passes to the hilum of the corresponding lung, where its ramifications commence. As in the trachea, each bronchus is cylindrical and firm in front and at the sides, but posteriorly it is flattened and membranous. There being certain differences between the bronchi, a separate description is required for each.

The **right bronchus** is about 1 inch in length up to the point where it gives off its first, or eparterial, branch. It has about six cartilaginous rings, and is larger than the left bronchus. It is more vertical than the left bronchus, and therefore coincides with the direction of the trachea to a greater extent than its fellow.

Relations—*Superior.*—The right azygos vein arches over it to open into the superior vena cava. *Posterior.*—The right pneumogastric nerve. *Inferior.*—The right pulmonary artery, which subsequently lies *anterior* to it.

About 1 inch from its commencement the right bronchus gives off a branch from its outer side which passes to the upper lobe of the right lung. This branch is known as the *eparterial bronchus*, because it arises above the right pulmonary artery. The rest of the right bronchus is spoken of as being *hyparterial.*

The **left bronchus** is about 2 inches in length. It has about twelve cartilaginous rings, and is smaller than the right bronchus on account of the smaller size of the left lung. Its course is more oblique than that of its fellow, and it is directed downwards and outwards beneath the arch of the aorta to the hilum of the left lung.

Relations—*Anterior.*—The left pulmonary artery, which subsequently lies *above* it. *Posterior.*—The œsophagus and the descending thoracic aorta.

The left bronchus has no eparterial branch.

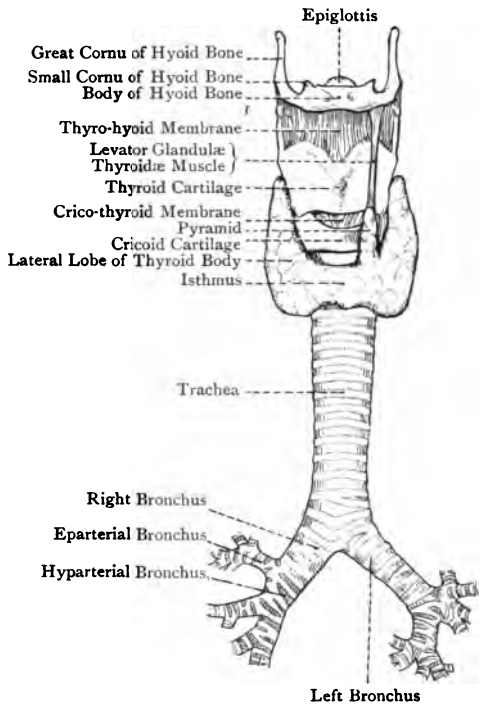


FIG. 403.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID BODY (ANTERIOR VIEW).

When the interior of the trachea is viewed from above, as in using the laryngoscope, the openings of the two bronchi are seen to be separated by a ridge which is situated to the left of the median line, and more of the interior of the right bronchus than of the left is visible. Partly on this account, and partly by reason of the more vertical direction of the right bronchus, as well as its larger size, a foreign body getting into the trachea is more apt to descend into the *right* bronchus than into the left.

The structure of the trachea will be described in connection with the description of the windpipe in the neck.

Œsophagus in the Thorax.—The œsophagus or gullet extends from the pharynx to the stomach. In the first part of its course it lies in the neck, and this portion will be found described in connection with that region. The **thoracic part** (see Fig. 405) extends from the level of the upper border of the manubrium sterni to the level of the body of the twelfth thoracic vertebra, where it passes through the œsophageal opening of the diaphragm, and terminates at the cardiac orifice of the stomach. Its course is not quite vertical. At its commencement the thoracic portion lies partially to the left of the middle line, but as it descends it comes to occupy a median position about the level of the fifth thoracic vertebra, and inferiorly it again inclines partially to the left. It occupies the superior and posterior mediastinal spaces, and lies in front of the vertebral column, accurately following the thoracic antero-posterior curve.

Relations—*Anterior.*—The trachea as low as the intervertebral disc between the bodies of the fourth and fifth thoracic vertebræ; the root of the left bronchus; the posterior wall of the pericardium, opposite the back of the left auricle of the heart; and the vertebral portion of the diaphragm. *Posterior.*—The vertebral column; the longus colli muscles, especially the left; the thoracic duct and right azygos vein; the right aortic intercostal arteries; the upper and lower transverse azygos veins; and, inferiorly, the descending aorta. *Right.*—The right posterior mediastinal pleura. *Left.*—The thoracic portion of the left subclavian artery; the upper part of the thoracic duct; the left posterior mediastinal pleura; and the descending aorta, except inferiorly.

The right and left pneumogastric nerves are intimately related to the œsophagus. They are at first disposed laterally, and their branches give rise to the *plexus gulæ*. Subsequently the right pneumogastric nerve descends on the posterior surface of the œsophagus, and the left on the anterior surface, in which positions they accompany the gullet through the œsophageal opening of the diaphragm.

Blood-supply—Arteries.—These are (1) the œsophageal branches of the descending aorta, (2) the œsophageal branches of the gastric artery from the cœliac axis, and (3) twigs from the left inferior phrenic artery. In the neck the œsophagus receives branches from the right and left inferior thyroid arteries.

The **veins** accompany the corresponding arteries, and terminate in the right azygos vein and the two left azygos veins.

Lymphatics.—These pass to the posterior mediastinal glands.

Nerves.—These are derived from the pneumogastric and sympathetic nerves.

Structure.—The wall of the œsophagus consists of three coats, namely, muscular, submucous, and mucous.

The **muscular coat** is thick, and is disposed in two layers, an external longitudinal, and an internal circular.

The *longitudinal muscular fibres* are attached superiorly to the upper part of the median ridge on the posterior surface of the cricoid cartilage, and from this point they descend as two flattened bands, one on either side of the tube. These expand and soon meet, giving rise to one continuous layer which completely surrounds the gullet. Inferiorly they are continuous with the longitudinal muscular fibres of the stomach. Accessory fleshy slips are described as passing from this layer to the back of the trachea, the back of the root of the left bronchus, the pericardium, and the left pleura.

The *circular muscular fibres* are continuous superiorly with the lower fibres of the inferior constrictor muscles of the pharynx, and inferiorly with the circular, and also with the oblique, muscular fibres of the stomach.

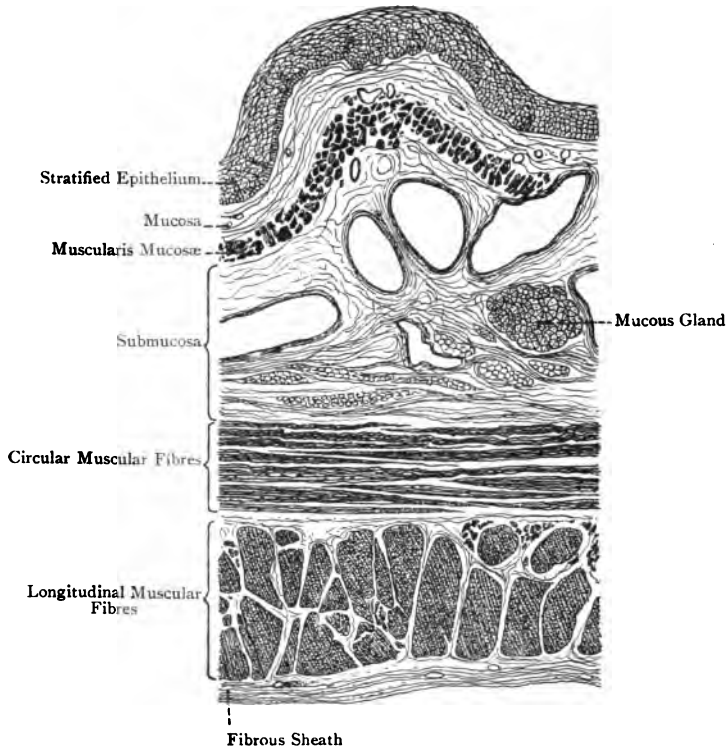


FIG. 404.—TRANSVERSE SECTION OF THE WALL OF THE ŒSOPHAGUS.

The muscular tissue of the œsophagus is of the striated variety over about the *upper third* of the tube, but elsewhere it is of the plain or non-striated variety.

The **submucous coat** consists of loose areolar tissue, which contains the larger bloodvessels and the mucous glands.

The **mucous coat** is thick, and is thrown into longitudinal folds, on account of the loose disposition of the submucous coat. The portion of it next the submucous coat consists of plain muscular fibres, which are arranged longitudinally. This portion is known as the *muscularis mucosæ*, and it is best marked in the lower part of the gullet. The inner surface of the mucous

coat is provided with numerous papillæ, and it is covered by stratified squamous epithelium, which is thrown into elevations by the papillæ.

The *mucous glands* are racemose, and are situated in the submucous coat. Their ducts are large and long, and on their way to the free surface some of them traverse small collections of lymphoid tissue.

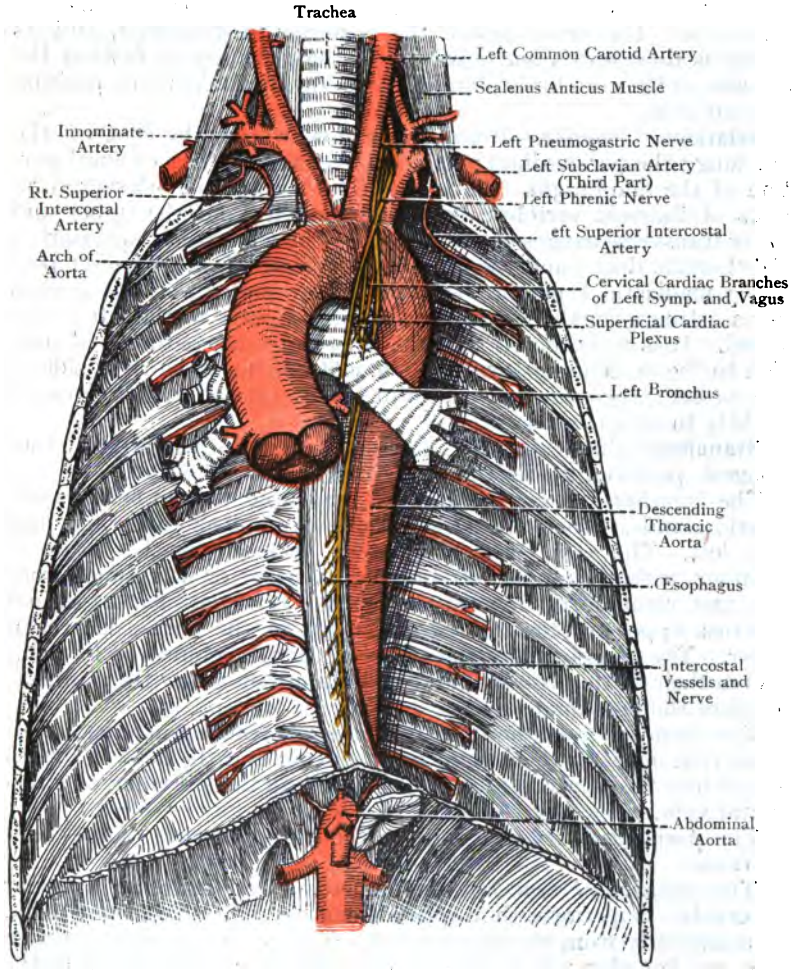


FIG. 405.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

Development.—The œsophagus is developed from that part of the fore-gut which succeeds to the portion from which the pharynx is developed. At first it is very short, on account of the imperfect development of the neck. As, however, the neck becomes formed, and as the stomach descends, the œsophagus becomes elongated.

Descending Aorta.—The descending aorta, which is the continuation of the aortic arch, commences on the left side of the body of the fourth thoracic vertebra on a level with its lower border, and it terminates at the lower border of the body of the twelfth thoracic vertebra. At the latter level it passes through the aortic opening of the diaphragm, and enters upon the abdominal part of its course. The vessel lies in the posterior mediastinum, and its course is downwards and inwards, so that, though at first on the left side of the vertebral column, it subsequently takes up a position in front of it.

Relations—*Anterior.*—From above downwards, the root of the left lung; the pericardium; the œsophagus; and the vertebral portion of the diaphragm. *Posterior.*—The bodies and intervertebral discs of thoracic vertebræ below the fourth; and the upper and lower transverse azygos veins. *Right.*—The œsophagus, superiorly; the thoracic duct; and the right azygos vein. *Left.*—The left posterior mediastinal pleura; and the upper and lower left azygos veins. Inferiorly the œsophagus inclines slightly to the left of the vessel. It is to be noted that the œsophagus has a threefold relation to the descending aorta. At first it lies upon the right side of the vessel; then directly in front of it; and finally it inclines slightly to its left side.

Branches.—These are as follows: bronchial, pericardial, œsophageal, posterior mediastinal, intercostal, and subcostal.

The *bronchial arteries* supply the lungs and the bronchial lymphatic glands. They are usually three in number—one right and two left. The *right* bronchial artery arises from the aorta in common with the upper left bronchial artery, or sometimes from the first right aortic intercostal artery. The *two left* bronchial arteries, upper and lower, arise directly from the aorta, near each other. The arteries enter the respective lungs behind the bronchi, and in their further course and distribution they follow the ramifications of the bronchial tubes.

The *bronchial veins* accompany the corresponding arteries. The *right* vein opens into the right azygos vein; and the *left* vein opens either into the upper left azygos vein, or into the left superior intercostal vein.

The *pericardial branches* supply the posterior part of the pericardium.

The *œsophageal branches* are numerous, and arise at irregular intervals. Superiorly they spring from the right side of the aorta, and inferiorly from its anterior wall. They anastomose freely with one another along the wall of the œsophagus; superiorly with the œsophageal branches of the inferior thyroid arteries; and inferiorly with the œsophageal branches of the gastric artery from the cœliac axis, the latter branches entering the thorax through the œsophageal opening of the diaphragm.

The *posterior mediastinal branches* are very minute, and supply the lymphatic glands and areolar tissue in the posterior mediastinum.

The **intercostal arteries** are arranged in pairs, and are nine in number on each side. They are destined for the lower nine intercostal spaces, the first two spaces being supplied by the superior intercostal artery, which is a branch of the second part of the subclavian on the right side, and of the first part on the left side. They arise in pairs from the posterior wall of the descending aorta, and they pass outwards upon the bodies of the vertebræ to the posterior extremities of the intercostal spaces. The arteries of the right side pass behind the œsophagus, the thoracic duct, and the right azygos vein; and those of the left side pass behind the upper and lower left azygos veins, according to their level. The arteries of both sides pass behind the gangliated cord of the sympathetic. The upper right intercostal arteries are longer than those of the left side, on account of the position of the descending aorta on the left side of the vertebral column. All the arteries lie behind the parietal pleura. Each artery, on entering an intercostal space, lies at first between the parietal pleura and the posterior intercostal aponeurosis. Its course is outwards and slightly upwards, and partly on this latter account, but chiefly on account of the downward slope of the rib, it soon gains the lower border of the upper rib. At a point corresponding to the angle of the rib the artery pierces the posterior intercostal aponeurosis, and, passing between the external and internal intercostal muscles, it enters the subcostal groove of the upper rib. In this position it courses forwards, and ends by anastomosing with the upper anterior intercostal branch of the internal mammary artery, or of its musculo-phrenic branch, according to the level.

The companion intercostal vein lies above the artery, and the corresponding intercostal nerve lies below it. The order of structures, therefore, in the subcostal groove, from above downwards, is as follows: intercostal vein, intercostal artery, and intercostal nerve. The upper seven aortic intercostal arteries are confined to the intercostal spaces which they occupy; but the lower two, namely, those in the tenth and eleventh intercostal spaces, ultimately leave these spaces, and pass into the abdominal wall, where they have been described in connection with the abdomen.

Branches.—These are dorsal, giving off a spinal branch; collateral; and lateral cutaneous.

The *dorsal branch* arises from the aortic intercostal artery as that vessel enters the posterior extremity of an intercostal space. It passes backwards, in company with the posterior primary division of the corresponding spinal nerve, between the adjacent transverse processes, where it lies internal to the superior costo-transverse ligament. Opposite the intervertebral foramen it gives off its *spinal branch*, which enters the spinal canal through the foramen to be distributed to its osseous and ligamentous walls, as well as to the spinal cord and its membranes. The dorsal branch, continuing its course backwards, divides into an internal and external branch, which supply the muscles and integument of the back.

The *collateral intercostal artery* arises from the main aortic intercostal opposite the angle of the rib. It passes obliquely downwards and outwards to the upper border of the lower rib, along which it courses, lying between the external and internal intercostal muscles. Anteriorly it ends by anastomosing with the lower anterior intercostal branch of the internal mammary artery, or of its musculophrenic branch, according to the level.

The *lateral cutaneous branches* accompany the lateral cutaneous branches of the corresponding intercostal nerves to the integument.

The *first* aortic intercostal artery, namely, that which lies in the *third* intercostal space, furnishes a branch, of variable size, which ascends over the neck of the third rib to the second intercostal space. This branch anastomoses with the second intercostal artery, which is a branch of the superior intercostal, and may even replace it.

The *subcostal arteries*, right and left, are the last branches of the descending thoracic aorta. They are serially continuous with the aortic intercostal arteries above, and with the lumbar arteries below. Each vessel winds round the side of the body of the twelfth thoracic vertebra, and, passing beneath the external arcuate ligament of the diaphragm, it enters the wall of the abdomen, where it lies along the lower border of the twelfth rib. These vessels will be found described in connection with the abdomen (see p. 726).

The first and second intercostal spaces receive their arteries from the *superior intercostal artery*, which is a branch of the second part of the subclavian on the right side, and of the first part on the left side. Having descended in front of the neck of the first rib to the posterior extremity of the first intercostal space, the vessel furnishes the first intercostal artery to that space, and it also gives off the second intercostal artery, which descends in front of the neck of the second rib to the second intercostal space. As stated, the second intercostal artery receives a branch from the third intercostal artery, which ascends over the neck of the third rib, the third intercostal being the first aortic intercostal.

Development of the Descending Aorta.—The upper portion of the descending aorta is developed from that part of the *left* primitive dorsal aorta which lies between the fourth left arterial arch and the place of junction of the two primitive dorsal aortæ. The greater portion of it, however, results from the union of the two primitive dorsal aortæ.

Intercostal Veins.—The intercostal veins are eleven in number on either side, and each lies in the subcostal groove above the corresponding aortic intercostal artery. In the region of the angle of the rib each vein receives the *collateral intercostal vein*, which accompanies the artery of that name. At the posterior extremity of an intercostal space each vein receives a large *dorsal branch*, which returns blood from the muscles and integument of the back, the dorsal spinal venous plexus, and the spinal canal. With the exception of the upper three or four veins, all the other intercostal veins pass inwards, behind the corresponding sympa-

thetic cord, on to the bodies of the thoracic vertebræ, from which they receive small twigs. Their mode of termination differs on the two sides. On the *right side* the veins, having passed behind the œsophagus, terminate in the right azygos vein. On the *left side* the lower four veins, namely, the eighth, ninth, tenth, and eleventh, open into the lower left azygos vein; and the succeeding three (or four), namely, the fifth, sixth, and seventh (and, it may be, the fourth also), open into the upper left azygos vein.

The **first intercostal vein** of each side accompanies the corresponding superior intercostal artery, and terminates in the innominate vein, or, it may be, in the vertebral vein, of its own side.

The **second** and **third intercostal veins** (and, it may be, the fourth) of each side unite to form the superior intercostal vein. The **right superior intercostal vein,** after a downward course, joins the upper part of the right azygos vein. The **left superior intercostal vein** ascends over the back part of the arch of the aorta, and opens into the left innominate vein. It sometimes receives the left bronchial vein as a tributary.

Summary of the Intercostal Veins—Right Intercostal Veins.—The first opens into the right innominate vein, or sometimes into the right vertebral vein. The second and third (and, it may be, the fourth also) unite to form the right superior intercostal vein, which opens into the right azygos vein. The lower eight (sometimes the lower seven) are direct tributaries of the right azygos vein.

Left Intercostal Veins.—The first opens into the left innominate vein, or sometimes into the left vertebral vein. The second and third (and it may be the fourth also) unite to form the left superior intercostal vein, which opens into the left innominate vein. The fifth, sixth, and seventh (and, it may be, the fourth also) terminate in the upper left azygos vein. The eighth, ninth, tenth, and eleventh are tributaries of the lower left azgyos vein.

The left superior intercostal vein is developed from two sources. The *upper part* is formed by the portion of the left primitive jugular vein below, and adjacent to, the commencement of the transverse jugular vein. The *lower part* is formed by the upper portion of the left cardinal vein.

Azygos Veins.—These are three in number, one right and two left.

The **vena azygos major** or **right azygos vein** commences in the abdomen as the *right ascending lumbar vein*, and enters the thorax through the aortic opening of the diaphragm, lying on the right side of the aorta, the thoracic duct intervening. It then ascends, under cover of the œsophagus, upon the bodies of the thoracic vertebræ, crossing in its course the right aortic intercostal arteries. Having reached the level of the fifth thoracic vertebra it leaves the vertebral column, and, arching forwards over the right bronchus, it opens into the superior vena cava, just before that vessel pierces the pericardium. In the thorax the right azygos vein continues to lie on the right side of the aorta, the thoracic duct intervening.

Tributaries.—These are as follows:

1. The right subcostal vein.
2. The lower seven (sometimes the lower eight) right intercostal veins.

3. The right superior intercostal vein.
4. The right bronchial vein.
5. Some œsophageal veins.
6. Some pericardial veins.
7. The lower and upper transverse azygos veins.

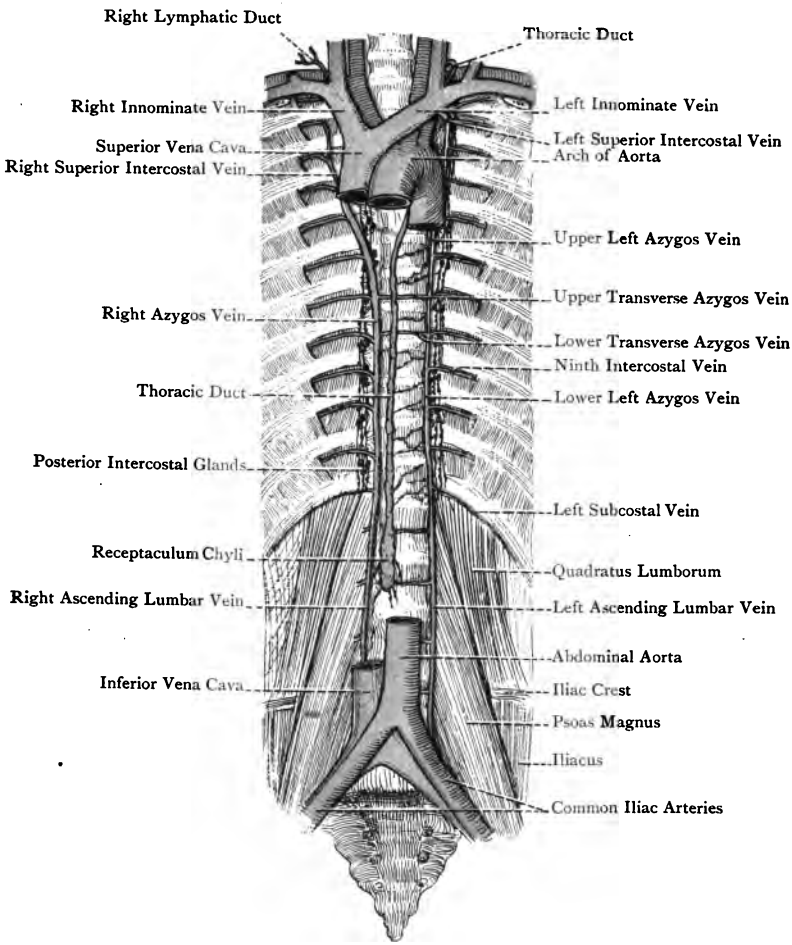


FIG. 406.—THE THORACIC DUCT, AZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

The **vena azygos minor** or **lower left azygos vein** commences in the abdomen as the *left ascending lumbar vein*, and enters the thorax by piercing the left crus of the diaphragm. It ascends upon the vertebral column to the level of the eighth thoracic ver-

tebra, lying in front of the lower aortic intercostal arteries, and it takes up the lower four left intercostal veins. It then crosses the vertebral column from left to right, under the name of the *lower transverse azygos vein*, passing behind the descending aorta and thoracic duct, and thereafter it opens into the right azygos vein.

Tributaries.—These are as follows:

1. The left subcostal vein.
2. The lower four left intercostal veins.
3. Some œsophageal veins.

The **upper left,** or **accessory, azygos vein** is formed by the union of the fifth, sixth, and seventh left intercostal veins (sometimes also the fourth). At the level of the seventh thoracic vertebra it crosses the vertebral column from left to right, under the name of the *upper transverse azygos vein*, passing behind the descending aorta and thoracic duct, and thereafter it opens into the right azygos vein. It communicates above with the left superior intercostal vein, and below with the lower left azygos vein.

Tributaries.—These are as follows:

1. The fifth, sixth, and seventh left intercostal veins (sometimes also the fourth).
2. The left bronchial vein, as a rule.
3. Some œsophageal veins.

The lower and upper left azygos veins, which are subject to much variation, sometimes unite to form one transverse azygos vein.

Summary of the Azygos Veins—Right Azygos Vein.—This vessel receives (1) the right subcostal vein; (2) the lower seven (sometimes the lower eight) right intercostal veins; (3) the right superior intercostal vein; (4) the right bronchial vein; (5) some œsophageal veins; (6) some pericardial veins; and (7) the lower and upper transverse azygos veins.

Lower Left Azygos Vein.—This vessel receives (1) the left subcostal vein; (2) the lower four left intercostal veins; and (3) some œsophageal veins.

Upper Left Azygos Vein.—This vessel receives (1) the fifth, sixth, and seventh (sometimes also the fourth) left intercostal veins; (2) the left bronchial vein, as a rule; and (3) some œsophageal veins.

The right azygos vein and the lower left azygos vein, through their connections with the ascending lumbar veins, establish communications with the inferior vena cava and with the common iliac veins or some of their tributaries. They therefore form important channels by which a considerable quantity of blood is returned from the lower limbs and abdominal wall in cases of obstruction of the inferior vena cava.

Development. — The **right azygos vein** is developed from the thoracic portion of the right cardinal vein. The **lower** and **upper left azygos veins** are developed from the thoracic portion of the left cardinal vein.

Subcostal Veins.—These are two in number, right and left, and they are serially continuous with the intercostal veins. Each vessel enters the thorax from the abdomen by passing behind the

external arcuate ligament of the diaphragm. As stated, the right vein opens into the right azygos vein, and the left into the lower left azygos vein.

Anterior Primary Divisions of the Thoracic Spinal Nerves.—These are twelve in number on each side. The first eleven enter intercostal spaces, and are called the **intercostal nerves.** The last, which belongs to the abdomen, lies along the lower border of the twelfth rib, and is called the **subcostal nerve** (' last dorsal nerve '). At the posterior extremities of the intercostal spaces the intercostal nerves are near the gangliated cord of the sympathetic, and each nerve is connected with the adjacent sympathetic ganglion by two *rami communicantes*, which are necessarily very short. One of these rami, being composed of spinal fibres, is *white*, and the other, which consists of sympathetic fibres, is *grey*. Each intercostal nerve lies below the corresponding artery, and, like it, lies between the parietal pleura and the posterior intercostal aponeurosis, as far as the angle of the rib. Its subsequent course corresponds to that of the artery. The first intercostal nerve is of small size, because the greater part of the anterior primary division of the first thoracic nerve takes part in the formation of the brachial plexus. The second intercostal nerve sometimes gives off a small branch which ascends to join the portion of the anterior primary division of the first thoracic nerve which takes part in the brachial plexus. The further course and distribution of the intercostal nerves belong to the thoracic and abdominal walls, in connection with which they will be found described.

Thoracic Duct.—The thoracic duct commences in the abdomen in a dilatation, called the **receptaculum chyli,** which is situated in front of the bodies of the first and second lumbar vertebræ, and it terminates by opening into the angle of junction of the internal jugular and subclavian veins of the left side. It is about 18 inches in length, and enters the thorax from the abdomen by passing through the aortic opening of the diaphragm, where it lies between the aorta on the left and the right azygos vein on the right. In this position it ascends in the thorax, resting upon the vertebral column, the right aortic intercostal arteries, and the lower and upper transverse azygos veins, being under cover of the œsophagus. Up to the level of the fourth or fifth thoracic vertebra it occupies the middle line. At this level it passes behind the arch of the aorta, inclining to the left of the middle line. Thereafter it ascends in close contact with the left side of the œsophagus, and behind the thoracic portion of the left subclavian artery. In this position it enters the root of the neck on the left side, where it ascends upon the left side of the œsophagus, between the left common carotid and left subclavian arteries. At about the level of the seventh cervical vertebra it describes a curve, and passes outwards, forwards, and downwards, in contact with the dome of the left pleura. Thereafter it inclines inwards, and terminates by opening into the angle of junction between the internal jugular and subclavian veins

of the left side. In the lower part of the thorax the thoracic duct is of smaller calibre than in the upper part. Its course is somewhat undulating, and when distended it presents a beaded appearance, especially in the upper part, due to the number of valves with which it is provided. Sometimes the duct divides into two branches in the lower part of the thorax, which reunite at a higher level. The duct is freely provided with valves, especially in its upper part, and at its termination there is an important valve, consisting of two segments, which are so directed as to prevent effectually the reflux of chyle, or the flow of blood, into the duct.

The thoracic duct receives lymphatic vessels from the following sources: (1) the lower limbs; (2) the abdomen and its viscera, except some of the lymphatics from part of the upper surface of the liver; (3) the left half of the thoracic wall; (4) the left lung and the left half of the heart; (5) the left upper limb; and (6) the left side of the head and neck. Most of the lymphatics of the right half of the thorax and those of the right lung and right half of the heart pass to the right lymphatic duct, for the description of which see the section dealing with the neck.

Thoracic Lymphatic Glands.—These are arranged in several groups, as follows: anterior intercostal or sternal, posterior intercostal, superior mediastinal, anterior mediastinal, posterior mediastinal, bronchial, and caval.

The **anterior intercostal** or **sternal glands** will be found described on p. 877. They receive their afferent vessels from (1) the anterior parts of the upper six intercostal spaces; (2) the inner portion of the mammary gland; (3) the lymphatics accompanying the superior epigastric artery from the upper part of the anterior abdominal wall; and (4) the lymphatics accompanying the musculo-phrenic artery from the anterior parts of the seventh, eighth, and ninth intercostal spaces, and from a portion of the diaphragm. The efferent vessels of the right glands terminate in the right lymphatic duct, and those of the left glands in the thoracic duct.

The **posterior intercostal glands** are situated on either side of the vertebral column, where they lie in the intercostal spaces, there being from one to three in each space. They receive their afferent vessels from (1) the posterior parts of the intercostal spaces; (2) the parietal pleura; (3) the spinal canal; and (4) the deep muscles of the back. The efferent vessels of the left intercostal glands open into the thoracic duct. On the right side the efferent vessels from the lower glands pass to the thoracic duct, but those from the upper glands open into the right lymphatic duct.

The **superior mediastinal glands** lie in the superior mediastinum in relation to the arch of the aorta and the innominate veins, and they are continuous with the posterior mediastinal and bronchial glands. They receive their afferent vessels from the pericardium, the heart, and the thymus body in early life, and their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **anterior mediastinal glands** lie in the lower part of the anterior

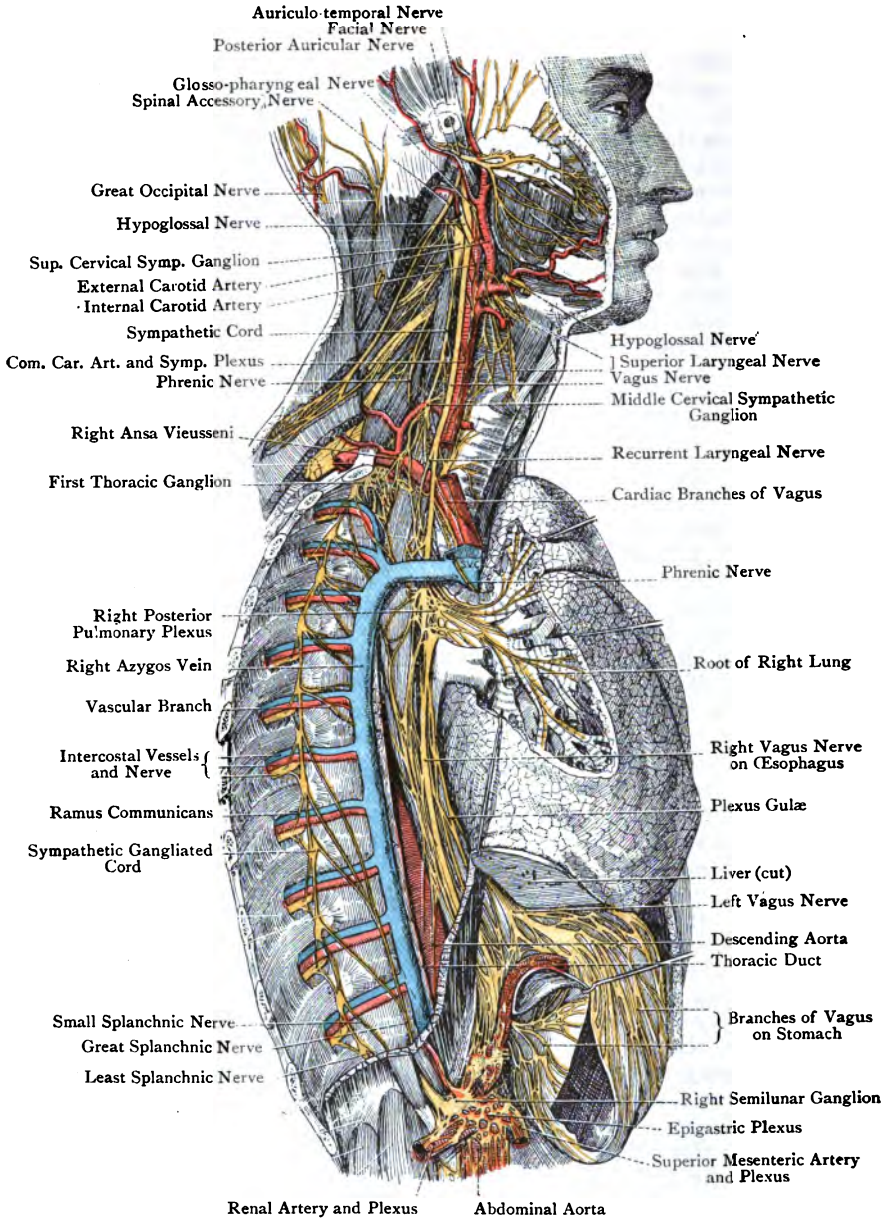


FIG. 407.—NERVES OF THE RIGHT SIDE OF THE FACE, NECK, AND THORAX (HIRSCHFELD AND LEVEILLÉ).

mediastinum, in front of the pericardium. They receive their afferent vessels from (1) the mesial portions of the right and left lobes of the liver in the vicinity of the falciform ligament; (2) the adjacent portion of the diaphragm; (3) the anterior part of the pericardium; and (4) the lower anterior intercostal or sternal glands. Their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **posterior mediastinal glands** are situated in the posterior mediastinum, along the course of the descending aorta and œsophagus. They receive their afferent vessels from the œsophagus, the posterior part of the pericardium, and the vertebral portion of the diaphragm. Their efferent vessels pass, for the most part, to the thoracic duct.

The **bronchial glands** are very numerous, and are situated partly between the two bronchi, where these spring from the trachea, and partly at the root of each lung. They are very dark in colour, and receive their afferent vessels from the lungs and the visceral pleuræ. Their efferent vessels pass to the thoracic duct and right lymphatic duct.

The **caval glands** are situated in contact with the limited thoracic portion of the inferior vena cava. They receive their afferent vessels from the uncovered area of the posterior surface of the liver, and also those deep lymphatics of that organ which accompany the hepatic veins to the caval fossa. Their efferent vessels pass to the thoracic duct.

Gangliated Cord of the Sympathetic.—The sympathetic system in the thorax consists of (1) two gangliated cords, right and left, and (2) a prevertebral plexus, namely, the cardiac plexus. The latter plexus has been already described. The gangliated cord lies on each side of the vertebral column behind the parietal pleura, and superficial to the intercostal vessels. It presents, as a rule, twelve ganglia, but the first is frequently united with the inferior cervical ganglion, in which cases the number is reduced to eleven. The upper ten ganglia are placed upon the heads of the corresponding ribs, but the lower two lie upon the sides of the bodies of the eleventh and twelfth thoracic vertebræ. The first thoracic ganglion is the largest of the thoracic series, and is known as the *ganglion stellatum*. The sympathetic cord leaves the thorax by passing behind the inner part of the internal arcuate ligament of the diaphragm, and so enters the abdomen.

Branches—1. **Of Communication.**—These are called the *rami communicantes*. Two of these, one *white* and the other *grey*, pass between each ganglion and the adjacent intercostal nerve. The white fibres are of spinal, and the grey of sympathetic, origin. From the proximity of the ganglia to the intercostal nerves the rami communicantes are characterized by their shortness.

2. **Of Distribution.**—From the upper five ganglia small *vascular branches* are given off, which are distributed to the coats of the thoracic aorta. From the second, third, and fourth ganglia *pul-*

monary branches are given off to the posterior pulmonary plexus. From the fifth ganglion downwards the three splanchnic ('visceral') nerves—great, small, and least—are given off.

The **great splanchnic nerve** arises by five separate roots from the fifth, sixth, seventh, eighth, and ninth ganglia, the fibres of the upper roots being traceable in the sympathetic cord as high as the second ganglion. The roots arch obliquely forwards and downwards upon the sides of the bodies of the adjacent vertebræ, and by their union they form a large nerve, which pierces the crus of the diaphragm and terminates in the semilunar ganglion of the epigastric or solar plexus. The great splanchnic nerve contains a large number of spinal fibres, which impart to it a white colour and firm consistence. The right nerve presents a small ganglion just before it leaves the thorax, called the *splanchnic ganglion*, and there may be one on the left nerve. The great splanchnic nerve gives vascular branches to the lower part of the thoracic aorta.

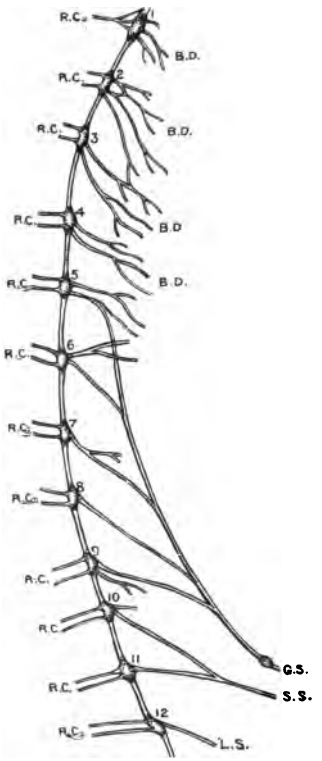


FIG. 408.—SCHEME OF THE GANGLIATED CORD OF THE SYMPATHETIC IN THE THORAX (AFTER FLOWER).

1 to 12. Thoracic Ganglia
R.C. Rami Communicantes
B.D. Branches of Distribution from Upper Ganglia
G.S. Great Splanchnic Nerve and Ganglion
S.S. Small Splanchnic Nerve
L.S. Least Splanchnic Nerve

The **small splanchnic nerve** arises by two roots from the tenth and eleventh ganglia. It pierces the crus of the diaphragm, and terminates in the aortico-renal ganglion of the epigastric or solar plexus.

The **least splanchnic nerve,** which is sometimes absent, arises by one root from the twelfth ganglion. It either passes behind the internal arcuate ligament of the diaphragm or through the crus, and it terminates in the renal plexus. When the least splanchnic nerve is absent, its place may be taken by a branch from the small splanchnic nerve.

Subcostal Muscles. — These are small indefinite muscular sheets, which lie on the inner surfaces of the ribs in the region of the angles. They coincide in direction with the internal intercostal muscles, and are best developed inferiorly. They are attached to the inner surfaces of the ribs

near the angles, and each muscle crosses over one, or it may be two, intercostal spaces.

They are supplied by the intercostal nerves.

The diaphragm will be found described in connection with the abdomen.

The Articulations of the Vertebral Column.

1. **Articulations of the Bodies of the Vertebræ.**—These joints belong to the class **amphiarthrosis.** The ligaments are as follows: the anterior common ligament, the posterior common ligament, and the intervertebral discs.

The **anterior common ligament** is a dense band of white glistening fibres, which extends over the anterior surfaces of the bodies of

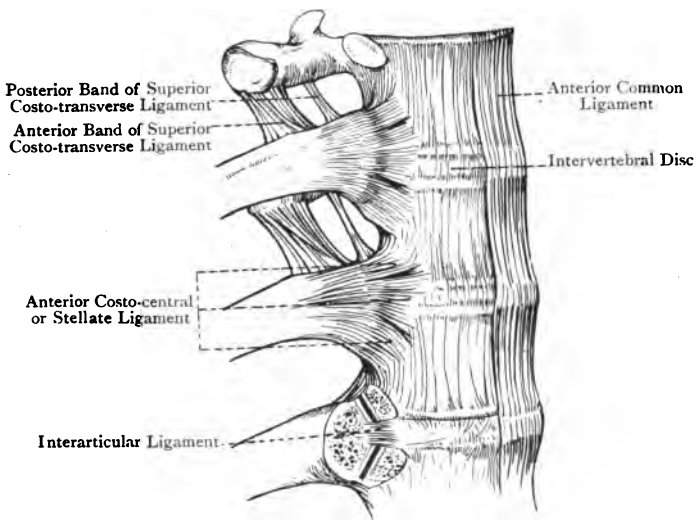

Posterior Band of Superior Costo-transverse Ligament
Anterior Band of Superior Costo-transverse Ligament
Anterior Costo-central or Stellate Ligament
Interarticular Ligament
Anterior Common Ligament
Intervertebral Disc

FIG. 409.—LIGAMENTS OF THE BODIES OF THE VERTEBRÆ AND RIGHT COSTO-CENTRAL JOINTS.

the vertebræ and intervertebral discs. It extends from the axis to the first segment of the sacrum, and its fibres are disposed longitudinally. The most superficial fibres extend from a given vertebra to the fifth below it; the intermediate fibres pass from a given vertebra to the third below it; and the deepest fibres pass from a given vertebra to the one immediately below it. The fibres are firmly attached to the intervertebral discs and margins of the vertebral bodies, but very loosely to the centres of the bodies, on account of the presence of bloodvessels. The anterior common ligament is broadest in the lumbar region, and thickest in the

thoracic region. It is thicker opposite the centres of the bodies than elsewhere, and in these situations it fills up the concavities, and so renders the front of the column less undulating than it otherwise would be. Over the lateral surfaces of the bodies a few scattered fibres are present, which pass from one vertebra to that below. In the sacral region the anterior common ligament is lost in the periosteum of the bone, but it reappears lower down as the anterior sacro-coccygeal ligament. The anterior common ligament is serially continuous superiorly with the anterior atlanto-axial ligament.

The **posterior common ligament** is situated within the spinal canal, and extends over the posterior surfaces of the bodies of the

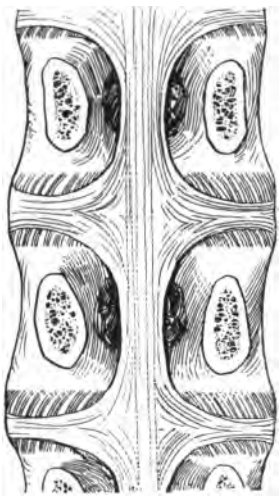


FIG. 410.—POSTERIOR COMMON LIGAMENT OF THE BODIES OF THE VERTEBRÆ.

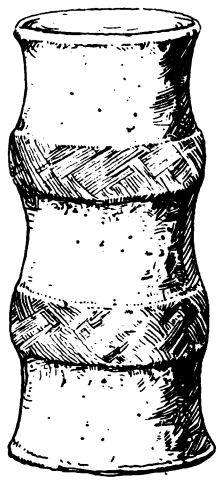


FIG. 411.—INTERVERTEBRAL DISCS (ANTERIOR VIEW).

vertebræ and intervertebral discs. It is broader above than below, and consists of glistening fibres, which extend from the axis to the first coccygeal vertebra, its sacral part, however, being very narrow and delicate. Its fibres are firmly attached to the intervertebral discs and margins of the vertebral bodies, but they are separated from the centres of the bodies by the transverse venous communications between the anterior intraspinal veins. In the cervical region the ligament is of almost uniform breadth, being expanded over the vertebral bodies, as well as over the intervertebral discs. In the thoracic and lumbar regions, however, it is narrow opposite the vertebral bodies, and broad opposite the intervertebral discs. Its margins, therefore, present dentations, which give it a denticulated appearance. The arrangement of its fibres is similar to the

arrangement of those of the anterior common ligament. The posterior common ligament is serially continuous superiorly with the posterior occipito-axial ligament.

The **intervertebral discs** are situated between the adjacent surfaces of the bodies of the vertebræ, and they constitute the chief bond of union between them. Their outline corresponds to that of the bodies between which they are placed, and they are elastic and compressible. Except in early life, the first or highest disc is situated between the bodies of the axis and the third cervical vertebra, and in the adult the last or lowest disc is situated between the bodies of the fifth lumbar and first sacral vertebræ.

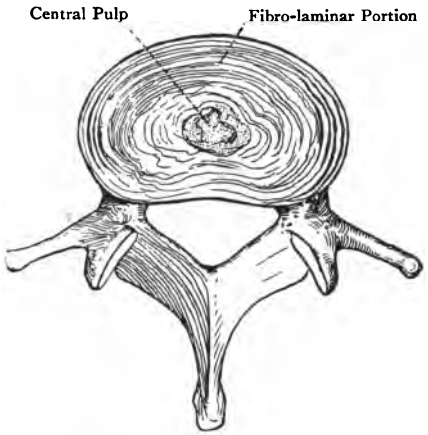


FIG. 412.—INTERVERTEBRAL DISC (TRANSVERSE SECTION).

Each disc is composed of a circumferential fibrous part, disposed in the form of superimposed laminæ, and a central portion, which is soft and pulpy. The *external laminar part* forms more than half of the disc, and is composed of fibrous tissue and fibro-cartilage. As seen in transverse section the laminæ are arranged concentrically around the central pulp, which they closely embrace and compress. The fibres of which they are composed are arranged in parallel bundles, which extend obliquely between the adjacent surfaces of the vertebral bodies, being attached to the layer of hyaline cartilage which covers them. The fibres of successive laminæ pass obliquely in opposite directions, and are disposed thus **X**. The outer laminæ consist of fibrous tissue, but the majority are composed of white fibro-cartilage. As seen in vertical section the outermost laminæ are bent outwards, and those around the central pulp are bent inwards towards it, this arrangement contributing to

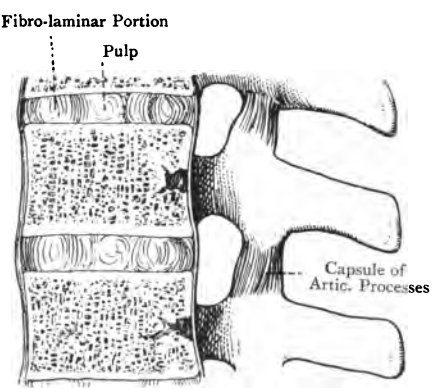


FIG. 413.—VERTICAL SAGITTAL SECTION OF TWO INTERVERTEBRAL DISCS.

the elasticity of the vertebral column. The *central portion* of the disc consists of a soft, elastic, pulpy substance, having a lobate arrangement. Being surrounded and compressed on all sides by the external laminar part, when a section of a disc is made the pulp, being relieved from pressure, projects beyond the level of the cut surface. It is composed of a cellular reticulum, supported by a delicate fibrous stroma.

The pulp is a persistent portion of the notochord.

The intervertebral discs form about one-fourth of the length of the vertebral column, and are thickest in the lumbar region. In the cervical and lumbar regions they are deeper in front than behind, and they give rise to the curve forwards in the cervical region, whilst they increase the forward curve in the lumbar region. In the thoracic region they are of uniform depth. Throughout the

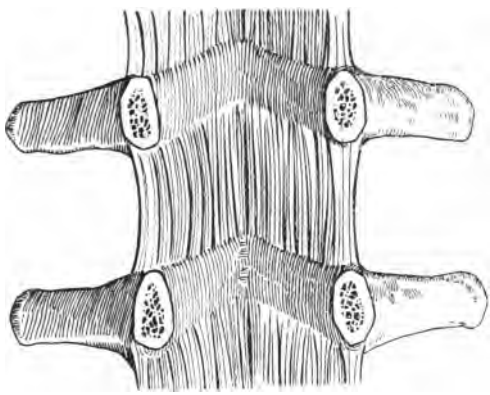


FIG. 414.—LIGAMENTA SUBFLAVA IN THE LUMBAR REGION (ANTERIOR VIEW)

(The Pedicles have been sawn through, and the Vertebral Bodies removed).

column they are intimately connected with the anterior and posterior common ligaments, and, in the thoracic region, with the anterior costo-central or stellate ligaments and the interarticular ligaments of the heads of most of the ribs. In the cervical region the discs are not present at either lateral aspect of the opposed surfaces of the bodies. In these regions there is a synovial space on either side, between the projecting lateral lip of the upper surface of the lower body and the bevelled lateral margin of the lower surface of the upper body. The opposed surfaces are covered by cartilage, and there is an indistinct capsular ligament.

2. **Ligaments of the Laminæ.**—These are called the **ligamenta subflava.** They are strong, thick plates of yellow elastic tissue, which connect the laminæ together, and they extend from the axis to the first sacral segment. They are best seen from the interior

of the spinal canal, and as they extend between the neural arches they close in the canal in these situations. Each ligamentum subflavum extends from the root of the articular process to the place where the lamina joins its fellow to form the spinous process. At this point it comes into relation with the ligament of the opposite side, a small interval being left between the two for the passage of veins. Superiorly the ligament is attached to the anterior surface of the upper lamina a little above its lower border, and inferiorly it is attached to the upper border, and adjacent part of the posterior surface, of the lower lamina. The ligamenta subflava are wider in the cervical and lumbar regions than in the thoracic region, and over the greater part of the latter region, as viewed from the exterior, they are concealed from view by the imbricated laminæ. Their importance consists in their great elasticity, which enables them to maintain the vertebral column erect, and to restore it to the erect position after it has been bent forwards.

3. **Ligaments of the Articular Processes.**—The joints between the articular processes belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The articular surfaces are covered by cartilage, and the joint is surrounded by a **capsular ligament,** lined with a synovial membrane. These ligaments are disposed more loosely in the cervical region than elsewhere.

4. **Ligaments of the Spinous Processes.**—These are supraspinous and interspinous.

The **supraspinous ligament** consists of longitudinal fibres which connect the extremities of the spinous processes. It extends from the spine of the seventh cervical vertebra to the spine of the fourth sacral segment, and its fibres are arranged in a manner similar to those of the anterior common ligament. In the cervical region the supraspinous ligament is replaced by the ligamentum nuchæ. The **interspinous ligaments,** which are thin and membranous, are situated between adjacent spinous processes, to the margins of which they are attached from root to tip. They are strongest in the lumbar region, and in the neck they are replaced by deep processes of the ligamentum nuchæ.

5. **Ligaments of the Transverse Processes.**—These consist of scattered fibres, which pass between the extremities of the transverse processes in the thoracic and lumbar regions. In the neck they are replaced by the intertransversales muscles.

Movements.—The movements allowed in the vertebral column are flexion, extension, lateral movement, rotation, and circumduction.

Flexion and **extension** are freely allowed in the cervical and lumbar regions. In the thoracic region these movements are very limited on account of (1) the small amount of intervertebral substance, and (2) the imbrication of the laminæ. **Lateral flexion** is allowed in the cervical, thoracic, and lumbar regions, but in the neck it is associated with rotation. During these combined movements of lateral flexion and rotation in the neck one inferior articular process glides upwards and forwards on that which is opposed to it, whilst the other inferior articular process glides downwards and backwards on the one opposed to it. Pure **rotation** is allowed in the thoracic region round an axis corresponding with the centre of a circle of which the surfaces

of the articular processes form segments. This centre is necessarily anterior to the articular processes, and corresponds pretty nearly with the centres of the bodies of the vertebræ. In the lumbar region rotation is impossible, for the following two reasons: (1) the centre of the circle of which the articular processes form segments is posterior to these processes; and (2) the articular processes are so disposed as to be locked. In the lumbar region **circumduction** is allowed, which consists in a combination of flexion, extension, and lateral movements.

Summary of Movements—Cervical Region.—(1) Flexion and extension; and (2) a combination of lateral flexion and rotation. **Thoracic Region.**—(1) Flexion and extension, but only to a limited extent; (2) lateral flexion; and (3) pure rotation. **Lumbar Region.**—(1) Flexion and extension; (2) lateral flexion; and (3) circumduction.

The articulations of the atlas, axis, and occipital bone will be found described in the section dealing with the head and neck.

THE ARTICULATIONS OF THE RIBS, COSTAL CARTILAGES, AND STERNUM.

1. **Ribs—Costo-vertebral Articulations.**—These are divided into costo-central and costo-transverse.

Costo-central Articulations.—These unite the heads of the ribs to the centra or bodies of the thoracic vertebræ, and they are sometimes spoken of as the *capitular joints*. They belong to the class **diarthrosis,** and to the subdivision **condylarthrosis.** The articular surfaces are the demi-facets on the heads of the ribs and the demi-facets on the sides of the bodies of the thoracic vertebræ, that is to say, the lower demi-facet of the vertebra above and the upper demi-facet of the vertebra below, the intervertebral disc intervening between the two. In the case of the 1st, (sometimes the 10th), the 11th, and the 12th vertebræ there is only one facet, and the corresponding intervertebral discs do not enter into the joints, unless in the case of the 1st joint, into which the disc between the 7th cervical and 1st thoracic vertebræ may enter.

Ligaments.—These are as follows: anterior costo-central, capsular, and interarticular.

The **anterior costo-central ligament** consists of strong white fibres which are attached to the anterior margin of the head of the rib. From this point the fibres radiate inwards in three bands, one of which passes upwards to be attached to the body of the vertebra above, a second horizontally inwards to be attached to the intervertebral disc, and a third downwards to be attached to the body of the vertebra below. From the radiating disposition of these bands the ligament is known by the name of **stellate** or **radiate.** In the case of the 1st, 10th, 11th, and 12th joints, into each of which only one vertebra enters, the ligament is composed of two bands, instead of three. In the 1st joint the lower band passes to the

body of the 1st thoracic vertebra, and the upper band to the body of the 7th cervical. In each of the 10th, 11th, and 12th joints the lower band passes to the body with which the head of the rib articulates, and the upper band to the body of the vertebra above.

The **capsular ligament** is incomplete, and consists of thin loose fibres, which cover the posterior, superior, and inferior aspects of the joint.

The **interarticular ligament** consists of short stout fibres, which extend from the ridge on the head of the rib, separating the two facets, to the intervertebral disc. It divides the joint into two complete synovial cavities, and it is wanting in the 1st, 10th, 11th, and 12th joints.

There are two distinct **synovial membranes** in those joints which are provided with an interarticular ligament, namely, from the

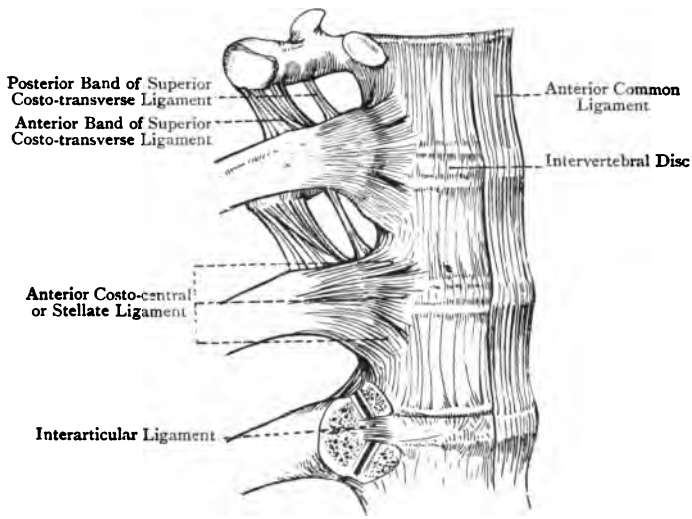

Posterior Band of Superior Costo-transverse Ligament
Anterior Band of Superior Costo-transverse Ligament
Anterior Costo-central or Stellate Ligament
Interarticular Ligament
Anterior Common Ligament
Intervertebral Disc

FIG. 415.—LIGAMENTS OF THE BODIES OF THE VERTEBRÆ AND RIGHT COSTO-CENTRAL JOINTS.

2nd to the 9th inclusive, one being above the ligament and the other below it. In those joints in which the interarticular ligament is absent, namely, the 1st, 10th, 11th, and 12th, there is only one synovial membrane.

Arterial Supply.—Branches from the intercostal arteries.

Nerve-supply.—Branches from the intercostal nerves.

Costo-transverse Articulations.—These belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The articular surfaces are the facet on the tubercle of the rib and the facet on the anterior aspect of the extremity of the transverse process of the thoracic vertebra.

Ligaments.—These are as follows: posterior costo-transverse, middle costo-transverse, superior costo-transverse, and capsular.

The **posterior costo-transverse ligament** is a strong flat band, situated on the posterior aspect of the joint, and extending from the extremity of the transverse process to the non-articular part of the tubercle of the rib. The direction of its fibres is upwards and outwards.

The **middle costo-transverse** or **interosseous ligament** consists of short strong fibres which pass between the posterior surface of the neck of the rib and the anterior surface of the adjacent transverse process, namely, that with which the tubercle of the rib articulates. Its fibres, which are disposed horizontally, extend from the costo-central to the costo-transverse joint. This ligament is rudimentary in the 11th and 12th ribs.

The **superior costo-transverse ligaments** are two in number, anterior and posterior. The *anterior* ligament is a broad flat band, external in position, the fibres of which pass from the crest on the upper border of the neck of the rib to the lower border of the transverse process immediately above, in the vicinity of its tip. Its fibres are directed upwards and outwards, and its outer border is continuous with the posterior intercostal aponeurosis. The *posterior* ligament is a narrow band, internal to the preceding, and extending from the back of the neck of the rib, below the crest, to the lower aspect of the transverse process immediately above, close to its base.

The superior costo-transverse ligaments are wanting in the case of the 1st rib.

The **capsular ligament** is formed in part by the posterior costo-transverse ligament, and elsewhere by a thin loose membrane, the fibres of which are attached external to the articular processes. It is absent in the case of the 11th and 12th ribs.

The **synovial membrane** is single and small.

Arterial and Nerve Supply.—Offsets from the posterior branches of the intercostal arteries and nerves.

The costo-transverse articulations are wanting in the case of the 11th and 12th ribs, and sometimes in the case of the 10th.

Costo-chondral Articulations.—These belong to the class **synarthrosis.** The outer extremity of the costal cartilage is implanted in the oval pit on the anterior extremity of the rib, and the union is effected by the continuity which takes place between the periosteum of the rib and the perichondrium of the cartilage.

2. **Costal Cartilages—Chondro-sternal Articulations.**—These belong to the class **diarthrosis,** and to the subdivision **ginglymus,** except in the case of the 1st joint, which belongs to the class **synarthrosis.** The cartilages which take part in these joints are the first seven on either side, these being received into the costal pits or facets on the side of the sternum.

The ligaments are anterior, posterior, superior, and inferior, and, in the case of the 2nd joint at least, interarticular.

The **anterior chondro-sternal ligament** is a triangular band, the upper fibres of which ascend upon the sternum, and the lower descend, whilst the intervening fibres pass horizontally forwards. They decussate with those of the opposite side, and blend with the tendinous fibres of origin of the pectoralis major muscle.

The **posterior chondro-sternal ligament** is disposed in a manner similar to the anterior ligament.

The **superior** and **inferior chondro-sternal ligaments** pass from the upper and lower borders of the costal cartilage to the side of the sternum.

The **interarticular ligament** is present in the 2nd joint, and may be present in some of those succeeding to it. Its fibres extend horizontally between the centre of the sternal end of the 2nd costal cartilage and the plate of fibro-cartilage between the manu-

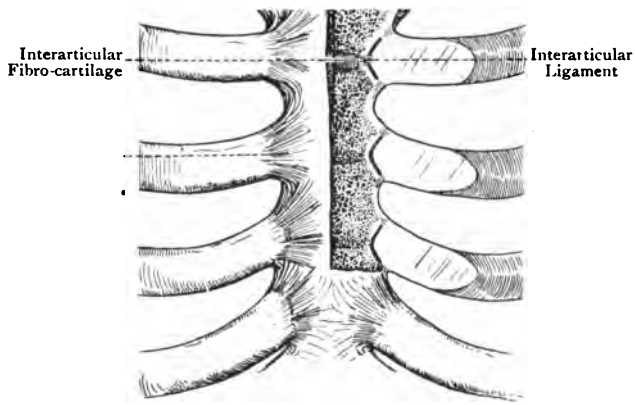


FIG. 416.—THE CHONDRO-STERNAL JOINTS (ANTERIOR VIEW).
The Second, Third, and Fourth Joints of the Left Side are seen in Section.

brium and body of the sternum. It divides this joint into two complete synovial cavities.

The 1st joint has no synovial membrane, the first costal cartilage being directly united to the manubrium sterni. The 2nd joint, as stated, has two synovial membranes, one above and the other below the interarticular ligament. The succeeding joints have each usually one synovial membrane, but sometimes one or more of them may have two.

Arterial Supply.—The anterior or perforating branches of the internal mammary artery.

Nerve-supply.—The intercostal nerves as they are becoming the anterior cutaneous nerves.

Interchondral Articulations.—These belong to the class **diarthrosis,** and to the subdivision **arthrodia.** The cartilages involved are usually the 6th, 7th, and 8th, but sometimes also the 9th,

and it may be the 5th, and even the 10th. The lower border of each cartilage projects downwards, and comes into contact with the upper border of the cartilage below, the contiguous surfaces being faceted. Each joint is surrounded by fibres disposed in the form of a capsule, and it is provided with a synovial membrane.

Arterial Supply.—The musculo-phrenic branch of the internal mammary artery.

Nerve-supply.—The adjacent intercostal nerves.

3. **Sternal Articulations.**—The joint between the manubrium and body of the sternum belongs to the class **amphiarthrosis.** The opposed surfaces are covered by hyaline cartilage, and a plate or disc of fibro-cartilage is interposed between them, which is connected at either side with the interarticular ligament of the second chondro-sternal joint. This disc may contain a small cavity. In front of and behind the joint there are ligamentous fibres which are disposed longitudinally.

The entire sternum is strengthened by its dense periosteum, by the radiating fibres of the chondro-sternal ligaments, and by the tendinous fibres of origin of the pectoralis major muscles.

Movements of the Ribs.—The movement allowed at the **costo-central** and **costo-transverse joints** is of a *gliding* nature, and takes place in an upward and downward direction. During this movement the rib *rotates* round the **costo-vertebral axis,** which corresponds to a line passing obliquely through the costo-central joint, the neck of the rib, and the costo-transverse joint. Owing to the curve and downward inclination of the rib, the result of this rotation is that the anterior and lateral parts of the rib are elevated. Simultaneously, on account of the obliquity of the axis of rotation, the anterior part of the rib is carried forwards, and along with it the sternum, thus increasing the *antero-posterior diameter* of the thorax. The lateral part of the rib, and to a certain extent the anterior part also, are carried outwards, thus giving rise to *eversion* of the lower border of the rib, and at the same time the angle between the rib and its costal cartilage is opened out. In this manner an increase in the *transverse diameter* of the thorax is produced. During the elevation of the anterior and lateral parts of the rib and the eversion of its lower border the movement takes place round the **costo-sternal axis,** which corresponds to a line drawn from the costo-central joint of one side to the corresponding chondro-sternal joint. It is usual to liken this movement to the movement of the handle of a bucket.

In the case of the first rib elevation and depression are the chief movements allowed, the amount of eversion being trivial, inasmuch as the axis of rotation is almost transverse. In the case of the second, third, fourth, fifth, and sixth ribs elevation and depression, along with eversion, are allowed, the axis of rotation in each case becoming successively more oblique. The seventh, eighth, ninth, and tenth ribs, in which the costo-transverse articular surfaces are almost flat, besides rotating round the costo-vertebral axis, also rotate round the costo-sternal axis. In the case of these ribs elevation is accompanied by a backward movement, and depression by a forward movement. These backward and forward movements take place more freely in the case of the eleventh and twelfth ribs, which have no costo-transverse joints. At the chondro-sternal joints the movement is limited, and consists in elevation and depression, together with forward and backward movement.

At the interchondral joints slight gliding movement is allowed.

Muscles concerned in Respiration.—In **ordinary quiet inspiration** the muscles concerned are as follows: (1) the diaphragm; (2) the external and internal intercostal muscles, assuming Haller's view to be correct; (3) the

levatores costarum ; (4) the serratus posticus superior ; (5) the serratus posticus inferior ; and (6) the quadratus lumborum, as being auxiliary to the diaphragm, the serratus posticus inferior being also auxiliary. **Ordinary quiet expiration** is due to (1) the elastic recoil of the lungs, (2) the elastic recoil of the thoracic wall (costal cartilages and sternum), (3) the triangularis sterni muscle, and (4) the muscles of the antero-lateral wall of the abdomen, which press mildly upon the abdominal viscera, and thereby push the diaphragm upwards towards the thorax.

In **forced inspiration** the following muscles come into play : (1) the scaleni ; (2) the sterno-cleido-mastoid ; (3) the serratus magnus ; (4) the pectoralis major and pectoralis minor ; and (5) the latissimus dorsi. As auxiliary muscles

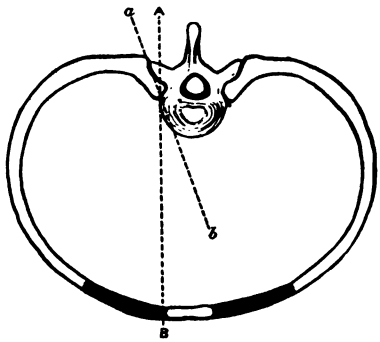


FIG. 417.—DIAGRAM SHOWING THE AXES OF ROTATION OF THE RIBS (FROM HALLIBURTON'S 'HANDBOOK OF PHYSIOLOGY').

A, B, Axis passing from Costo-central to Chondro-sternal Joint ; *a*, *b*, Axis passing through Costo-transverse and Costo-central Joints. (The movement round the axis A, B resembles the raising of the handle of a bucket.)

there are the trapezius, levator anguli scapulæ, and rhomboid muscles, which, by their action upon the scapula, fix the shoulder.

In **forced expiration** the muscles of the antero-lateral wall of the abdomen act with considerable strength, and now depress those ribs with which they are connected, and necessarily also the sternum. By some authorities the serratus posticus inferior is regarded as being concerned.

In inspiration the thoracic cavity is enlarged in its vertical, antero-posterior, and transverse diameters. The increase in the **vertical diameter** is due to the contraction and descent of the diaphragm ; the increase in the **antero-posterior diameter** is caused by the anterior parts of the ribs, and along with them the sternum, being carried forwards ; and the increase in the **transverse diameter** is brought about by the eversion of the lower borders of the ribs, and the opening out of the angles between the ribs and their costal cartilages.

GUIDE TO THE THORAX.

Thoracic Wall.—The upper limb having been separated from the trunk, the dissector should remove the remains of the following muscles : the pectoralis major, pectoralis minor, tendon of origin of the subclavius, serratus magnus, obliquus externus abdominis, latissimus dorsi, and rectus abdominis. In removing the remains of the pectoralis major the anterior cutaneous nerves

should be preserved, as well as the perforating branches of the internal mammary artery. In removing the serrations of the serratus magnus the lateral cutaneous nerves and arteries, which appear between them, should also be preserved.

The insertions of the scalenus anticus and scalenus medius into the first rib, and of the scalenus posticus into the second rib, are to be left intact in the meantime. If the sternum has not been interfered with, for the purpose of injecting the subject from the ascending aorta, the dissector should make himself familiar with the sternal angle at the junction of the manubrium and body of the sternum. In this connection he should note that the angle serves as the guide to the second rib, the cartilage of which articulates partly with the manubrium, and partly with the body of the bone.

The external intercostal muscle is to be dissected in at least two intercostal spaces. The direction of its fibres is to be carefully observed, and it is to be noted that the muscle does not extend farther forwards than the junction of the osseous rib with its costal cartilages; indeed, in some cases not so far as this. The anterior intercostal aponeurosis is also to be shown in the intervals between the costal cartilages. In one or more spaces a small portion of the external intercostal muscle is to be carefully divided transversely, and reflected upwards and downwards in two pieces. This dissection will expose a limited portion of the internal intercostal muscle, and it will enable the dissector to contrast the difference in direction of the two muscles. In another space as much of the external intercostal muscle as possible should be detached from the upper border of the lower rib, and turned upwards with great care, preserving at the same time the lateral cutaneous nerve and artery. The anterior intercostal aponeurosis of the same space should also be carefully removed, care being taken to preserve the anterior cutaneous nerve and perforating artery. This dissection will expose the internal intercostal muscle, the intercostal nerve, and the various intercostal arteries. The direction of the fibres of the internal intercostal muscle is to be observed, and it is to be noted that the muscle extends quite up to the lateral border of the sternum, where it is pierced by the anterior cutaneous nerve.

The intercostal nerve will be found *under cover of* the lower border of the upper rib, where it lies in the subcostal groove, having the aortic intercostal artery above it, the intercostal vein being in turn above the artery. It is well, therefore, to make slight traction upon the nerve before attempting to display it, and for this purpose the lateral cutaneous nerve will suffice, which is one reason for preserving that nerve. The first intercostal nerve, as a rule, gives off no lateral cutaneous branch, and those of the succeeding nerves will be found piercing the external intercostal muscles about midway between the vertebral column and the sternum. Up to this point the intercostal nerve will be met with between the two intercostal muscles, but subsequently it lies in the substance of the internal intercostal muscle, and finally, between the costal cartilages, it is placed beneath the internal intercostal muscle.

The arteries to be dissected in each space are as follows: (1) the aortic intercostal and its collateral intercostal branch, both passing forwards, the former within the lower border of the upper rib, above the nerve, and the latter along the upper border of the lower rib; and (2) the anterior intercostal arteries, two in each space, except the lower two spaces, one lying along the lower border of the upper rib, and the other along the upper border of the lower rib. The internal intercostal muscle should now be carefully removed, after which an instructive view of the parietal pleura will be obtained. This, however, must be left intact.

The dissector is next to turn his attention to the internal mammary vessels and anterior intercostal or sternal glands. These structures are to be displayed in a different manner on the two sides.

On one side the costal cartilages are not to be interfered with in the meantime, and on the other side the second, third, fourth, fifth, and sixth costal cartilages are to be cut through at their inner and outer ends, and then lifted

out. On both sides the anterior intercostal aponeuroses and interchondral fibres of the internal intercostal muscles should be removed. The internal mammary artery and its branches, along with its venæ comites, and the anterior intercostal or sternal glands are then to be dissected. The artery will be found about ½ inch from the side of the sternum, and its superior phrenic branch (comes nervi phrenici) is to be preserved until a later period. The venæ comites are also to be subsequently shown uniting superiorly to form one vessel. In the sixth intercostal space the internal mammary artery is to be shown dividing into its two terminal branches, namely, musculo-phrenic and superior epigastric. The triangularis sterni muscle is then to be dissected from before. On the side on which the costal cartilages have been left intact they are now to be cut through from the second to the sixth inclusive, close to the osseous ribs. Thereafter the ribs corresponding to these costal cartilages on each side are to be divided with the bone-forceps, and this should be done as far back as possible by turning the subject round on either side. The divided ribs are then to be bent backwards, the parietal pleura having been carefully separated from them. The sternum, meanwhile, is to be left undisturbed, with whatever costal cartilages are attached to it. The parietal pleura is then to be carefully studied. By way of showing that it does not descend as low as the line of attachment of the diaphragm, the external and internal intercostal muscles of one or two of the lowest spaces should be removed, when it will be seen that the diaphragm comes into view without any trace of parietal pleura.

The manubrium sterni is next to be partially sawn through near its lower border, the seventh costal cartilage on each side is to be cut through, and the great bulk of the sternum is then to be bent upwards in such a manner that it can be replaced when required. If the bone should break, the two parts should be connected by wire sutures. The relations of the anterior borders of the two pleural sacs to the sternum, to each other, and to the pericardium, are now to be carefully studied. The anterior mediastinum and the remains of the thymus body are to be inspected, and the area of the pericardium which is uncovered by the left pleura, and is directly related to the thoracic wall, is to receive special attention.

At this stage an opening should be made in the cervical portion of the trachea, and a blow-pipe, provided with a stop-cock, should be introduced and tied firmly in position. The lungs are now to be inflated through the blow-pipe, the stop-cock is to be turned, and the following points are to be accurately observed: (1) the extent to which the lungs encroach upon the heart, enclosed within the pericardium; and (2) the extent to which they descend between the diaphragm and the ribs. By reversing the stop-cock the lungs will be seen to collapse and recede from the precordial area. During these observations the greater part of the sternum should be alternately raised and lowered.

The chief part of the sternum is now to be removed, along with whatever costal cartilages are connected with it. On the side on which the cartilages remain in connection with the bone the triangularis sterni and the internal mammary vessels are to be dissected from behind. The chondro-sternal joints may be dissected at this stage, or it may be convenient to preserve the sternum for their future dissection.

Phrenic Nerves, Pleuræ, Pericardium, and Lungs.—Before the further stages of the dissection are entered upon, it is necessary that the dissector should have some knowledge of the general position of the structures to be exposed. From their complicated nature it is not possible to lay down hard-and-fast directions, and in his mode of procedure he must keep a careful look-out.

The phrenic nerve is to be dissected, and its close relation to the pericardium is to be noted, as well as its course in front of the root of the lung. Possibly the superior phrenic branch (comes nervi phrenici) of the internal mammary artery may be found coming into contact with the nerve high up in the thorax. The reflections of the pleura are to be studied both in the transverse and in the vertical directions. If any adhesions are present, these should be separated with the fingers, and any fluid which has accumulated must be

removed, and the parts thoroughly cleansed. The lines of the sternal and costo-diaphragmatic reflections of the pleura are to be carefully studied. In examining the antero-posterior reflections of the membrane the ligamentum latum pulmonis, below the root of the lung, is to be noted, and the mediastinum thoracis, with its divisions, is to receive very careful attention, these divisions being anterior, superior, middle, and posterior. The two pleural sacs which form the lateral boundaries of the anterior mediastinum are to be separated, when the middle mediastinum will be exposed, with the pericardium, enclosing the heart, lying in it.

The lungs are next to be studied. They have been already examined in their inflated and collapsed conditions, but attention is now to be directed to their form, component parts, fissure or fissures, and lobes. The differences between the two lungs are also to be noted, which impress corresponding differences upon the pleural sacs. The roots of the lungs are not to be dissected at this stage.

The superior mediastinum should now be examined, without disturbing the pericardium, and the remains of the thymus body, together with the superior mediastinal glands, are to be dissected.

The right and left innominate veins are next to receive attention, and their inferior thyroid and internal mammary tributaries, with, in some cases, the first intercostal vein, are to be noted. The left superior intercostal vein is to be displayed as an additional tributary of the left innominate vein, which it joins not far from its commencement, after having crossed the back part of the arch of the aorta.

The superior vena cava, formed by the junction of the two innominate veins, is to be shown and followed down to where it pierces the pericardium, but no farther in the meantime. The right azygos vein is to be displayed arching over the root of the right lung, and opening into the superior vena cava just before that vessel pierces the pericardium.

The pericardium is now to be studied from the exterior. Connected with its anterior wall parts of the superior and inferior sterno-pericardial ligaments of Luschka are to be looked for. The relation of the fibrous portion of the pericardium to the diaphragm is to be looked to, and its disposition upon the great vessels at the base of the heart, for which it forms sheaths, is to receive attention.

The intimate relation of the phrenic nerves to the pericardium has been already noted. The pericardium is now to be laid open by means of a vertical median incision, extending over its entire length, and a transverse incision opposite the roots of the lungs. The serous portion of the pericardium is then to receive careful attention. It is to be observed that, being a serous membrane, it is composed of parietal and visceral portions, which enclose between them a shut sac. The close relation of the parietal portion to the fibrous part is to be noted, and the disposition of the visceral portion upon the ascending aorta and trunk of the pulmonary artery is to be carefully studied. It will be seen to form a single sheath for them, and to rise upon the ascending aorta for from 1 to 1½ inches. The transverse sinus of the pericardium should be explored with the finger. It will be found lying behind the ascending aorta and trunk of the pulmonary artery, and in front of the auricular portion of the heart. In connection with the serous portion of the pericardium the triangular fold, called the vestigial fold of Marshall, is to be looked for in front of the root of the left lung, between the left pulmonary artery and the subjacent pulmonary vein. When this fold is carefully dissected it will be found to contain a delicate fibrous cord, which is a vestige of the left duct of Cuvier of embryonic life.

The pericardium is now to be removed, which will show the lower part of the superior vena cava. The heart, being now exposed, should receive the most careful attention. Its external form and component parts are to be observed, and the relations of these parts to the thoracic wall must be thoroughly mastered. More especially the relation of the valvular orifices of the heart to the thoracic wall calls for the closest observation. The trunk of the pulmonary artery is to be studied, as it springs from the conus arteriosus

at the base of the right ventricle, and it is to be noted that it conceals the origin of the aorta from the base of the left ventricle. Further, it will be seen that both of these vessels are embraced by the auricular appendices.

The right and left coronary arteries, each accompanied by the corresponding coronary plexus of nerves, are to be displayed as they come forwards on either side of the root of the pulmonary artery. The superior vena cava is to be shown opening into the postero-superior angle of the right auricle, and, by raising the heart, the inferior vena cava will be seen to open into the postero-inferior angle of the right auricle. The four pulmonary veins, two right and two left, will be found to open into the back part of the left auricle.

The ascending aorta is to be dissected, and in conjunction with it the trunk of the pulmonary artery, the superior vena cava being also kept in view. The arch of the aorta is next to be dissected, along with the innominate artery, and the thoracic portions of the left common carotid and left subclavian arteries.

Crossing in front of the aortic arch will be found the left phrenic and left pneumogastric nerves, and between them the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both of these two small nerves being on their way to the superficial cardiac plexus.

The left recurrent laryngeal nerve is to be shown arising from the left pneumogastric opposite the lower margin of the arch of the aorta, and passing backwards beneath the arch, and then upwards behind it, where it gives off one or two cardiac branches to the deep cardiac plexus. The left superior intercostal vein will be seen crossing over the back part of the arch on its way to the left innominate vein.

Within the concavity of the arch, in addition to the left recurrent laryngeal nerve, the superficial cardiac plexus of nerves and the ligamentum ductûs arteriosi fall to be dissected. The superficial cardiac plexus lies in front of the trunk of the pulmonary artery, close to its bifurcation, and on the right side of the ligamentum ductûs arteriosi, and it requires the most careful dissection. The best way to proceed is to follow downwards from the front of the arch of the aorta the superior cervical cardiac branch of the left sympathetic and the inferior cervical cardiac branch of the left pneumogastric, both of which will conduct to the plexus. In this plexus a small ganglion, called the ganglion of Wrisberg, is to be looked for. The plexus itself will be found to furnish delicate filaments to the left anterior pulmonary plexus, after which it is prolonged into the right coronary plexus, which latter is reinforced by fibres from the right half of the deep cardiac plexus. The ligamentum ductûs arteriosi will be found extending from the root of the left pulmonary artery to the under aspect of the arch of the aorta immediately beyond the place of origin of the left subclavian artery.

The left lung is now to be turned well forwards, and fixed in that position by hooks. The trunk of the left pneumogastric nerve is to be followed downwards behind the root of the left lung. Before reaching that point it is to be shown furnishing a few branches which pass to the front of the root, and there form the small anterior pulmonary plexus. Behind the root of the left lung the nerve will be found to become flattened, and to break up into a number of branches, which form the posterior pulmonary plexus. From this plexus the nerve is to be shown issuing as two cords which pass downwards to the œsophagus, where they are to be left in the meantime. The right pneumogastric nerve will be found behind the right innominate vein, and on the right side of the right innominate artery and trachea. A little above this point the nerve has crossed over the first part of the right subclavian artery, and parted with the right recurrent laryngeal nerve opposite the lower margin of that vessel. The right pneumogastric nerve will be seen to occupy a much deeper position than the left. A branch to the deep cardiac plexus should be looked for coming from it, and the main nerve is to be followed downwards behind the root of the right lung, that organ having been turned well forwards, and kept in that position by hooks. Behind the root of the right lung the right pneumogastric nerve acts in a manner similar

to the left nerve, and forms the right posterior pulmonary plexus, from which it emerges as two cords, and these, as on the left side, descend to the œsophagus.

fThe lungs having been replaced in position, the root of each is now to be ully dissected, the bronchus, pulmonary artery, and pulmonary veins being clearly separated from each other all round the root. In performing this dissection the anterior and posterior pulmonary plexuses of nerves, already referred to, are to be studied, and the bronchial lymphatic glands are to be displayed. These glands are usually quite black, this being due to the deposit of carbonaceous matter in them. The general relations of each root, and the special relations of the chief constituents, are to be thoroughly mastered.

The right and left pulmonary arteries should now be examined from their origin from the main trunk to the root of each lung, and their relations are to be noted, as well as the ligamentum ductûs arteriosi in connection with the root of the left pulmonary artery. The pulmonary veins on each side are also to be followed from the root of the lung to the back part of the left auricle of the heart. In the dissection of the roots of the lungs the bronchial arteries, one right and two left, and the bronchial veins are to be kept in view.

Exterior of the Heart.—The dissection of the heart is now to be proceeded with. Its external form is to be carefully examined; the directions of the base, apex, and borders are to be observed; and the grooves by which it is divided into auricular and ventricular portions, and these, in turn, into right and left auricles, and right and left ventricles, are to be noted. The apex will be seen to be formed entirely by the left ventricle.

The right and left coronary arteries are to be fully dissected, and their origins from the root of the ascending aorta clearly shown, the trunk of the pulmonary artery being displaced as may be required. The right coronary artery is to be followed along the front and back of the right auriculo-ventricular groove, and its marginal branch is to be shown passing along the margo acutus. On the back of the heart the main vessel will be found to divide into two terminal branches, transverse and descending. The transverse branch is to be followed into the back part of the left auriculo-ventricular groove, where it anastomoses with the transverse branch of the left coronary artery; and the descending branch is to be followed along the inferior interventricular groove as far as the region of the apex, where it anastomoses with the descending branch of the left coronary artery.

The left coronary artery is to be shown dividing very early into a transverse and descending branch on the left side of the root of the pulmonary artery. The transverse branch is to be followed round the left auriculo-ventricular groove, and its marginal branch is to be shown passing along the margo obtusus vel rotundus. The descending branch is to be followed along the antero-superior interventricular groove as far as the region of the apex.

In dissecting the coronary arteries the right and left coronary plexuses of nerves are to be kept in view, and the various cardiac veins are to be at the same time displayed.

In the back part of the left auriculo-ventricular groove the coronary sinus, about 1 inch long, will be found, and its dilated condition is to be noted. The great cardiac or coronary vein (anterior interventricular vein) will be found in the antero-superior interventricular groove, along with the descending branch of the left coronary artery. On entering the front part of the left auriculo-ventricular groove (where it is now strictly the great cardiac or coronary vein), it should be followed, in company with the transverse branch of the left coronary artery, to the back part of the groove, where it will be found to become continuous with the coronary sinus. The middle cardiac vein (posterior interventricular vein) will be met with in the inferior interventricular groove, where it accompanies the descending branch of the right coronary artery, and it should be shown to join the right extremity of the coronary sinus. The right or small cardiac or coronary vein will be

found in the back part of the right auriculo-ventricular groove, and, it may be, in the front part of it. The anterior cardiac veins will be found on the front of the right ventricle and along the margo acutus, and they are to be traced to the right coronary vein. The posterior cardiac veins will be found on the inferior surface of the left ventricle, and they are to be followed to the lower border of the coronary sinus. The oblique vein of Marshall is to be carefully looked for on the back of the left auricle, along which it passes downwards and inwards to open into the left extremity of the coronary sinus. The tributaries of this sinus are now to be fully reviewed, and thereafter it is to be laid open with scissors. This will bring into view a valve, composed of two segments, which is situated at the place where the great cardiac or coronary vein opens into the sinus, namely, about 1 inch from the ending of the sinus in the right auricle.

The very delicate nerves derived from the coronary plexuses course upon the surfaces of the ventricles, but in the human heart they do not lend themselves very readily to inspection. The heart of the calf is much more favourably disposed for their examination.

Interior of the Heart.—In this dissection the best way to proceed is to follow the course of the blood through the heart. The right auricle is to be laid open by two incisions as follows: (1) a vertical incision is to be made from the auricular extremity of the superior vena cava to near the point of entrance of the inferior vena cava, keeping clearly in front and to the left of it, in order not to injure the vestigial Eustachian valve which is associated with its orifice; and (2) an oblique incision is to be made from the auricular appendix to about the centre of the vertical incision. Having removed the venous blood and sponged the interior of the auricle, the following points are to receive attention: (1) the musculi pectinati, situated on the wall of the auricular appendix and the adjacent portion of the right wall of the atrium; (2) the crista terminalis; (3) the fossa ovalis and annulus ovalis on the interauricular septum; (4) the so-called tubercle of Lower; (5) the vestigial Eustachian valve in connection with the orifice of the inferior vena cava; (6) the opening of the coronary sinus, and the Thebesian valve; (7) the foramina Thebesii; and (8) the auriculo-ventricular orifice. It is to be noted that no valve guards the opening of the superior vena cava.

In connection with the annulus ovalis a very minute opening may be found under cover of it, leading into the left ventricle. Its possible presence may be determined by exploring with a fine probe. Three fingers, held side by side, should be passed through the auriculo-ventricular orifice, and, if normal, it will be found to admit them readily.

The right ventricle is to be opened by means of two incisions, the left forefinger having previously been passed through the auriculo-ventricular orifice. A transverse incision is to be carried along the upper part of the ventricle, just below and parallel to the auriculo-ventricular groove. This incision is to be prolonged as far as a point below the root of the pulmonary artery. The other incision is to commence at the left end of the foregoing incision, and is to be carried downwards just to the right of the antero-superior interventricular groove. In this manner a triangular flap, representing the front wall of the right ventricle, can be turned down, and the cavity fully exposed. The second incision, just stated, may be replaced by one extending along the margo acutus to the lower end of the antero-superior interventricular groove, and then a triangular flap would be raised towards the left.

After cleansing the ventricle, the dissector is to observe (1) that its cavity is excluded from the apex of the heart, (2) that it is prolonged to the root of the pulmonary artery as the infundibulum or conus arteriosus, and (3) that the interventricular septum bulges into it, so as to be convex on its right aspect. The fleshy elevations, called columnæ carneæ, are to receive attention, their various kinds are to be noted, and special attention is to be given to the variety known as the musculi papillares. These latter will be found to be disposed in two groups—anterior and posterior. The absence of columnæ carneæ from the infundibulum is to be noted, and the moderator band is to be looked for extending from the anterior papillary muscle to the interven-

tricular septum. The tricuspid valve is next to receive attention, and its three main segments are to be carefully studied, the small secondary segments lying between their basal parts being noted. The chordæ tendineæ and their relations to the segments of the tricuspid valve should be closely examined, and the function of that valve is to receive careful consideration. The study of the pulmonary valve, which guards the orifice of the pulmonary artery, is to be postponed till a later period.

On account of the posterior position of the left auricle, and preparatory to opening it, the inferior vena cava may be divided in order to liberate the heart from the diaphragm. The heart is then to be turned over to the right side, and also upwards. A transverse incision may then be made above and parallel to the auriculo-ventricular groove, and any other which may suggest itself to the dissector, who is supposed to know by previous study the internal arrangement of the parts. The interior having been cleansed, it will be at once apparent that the musculi pectinati are confined entirely to the region of the auricular appendix. On examining the left surface of the interauricular septum the position of the foramen ovale of the fœtal heart, and the remains of the valve which originally closed it, will be recognised as a slight depression, which is limited inferiorly by a crescentic border with the concavity directed upwards. It may be compared to the imprint of a finger-nail.

The orifices of the pulmonary veins on the posterior wall—two right and two left—are to be examined, and the absence of valves noted. The left auriculo-ventricular orifice is next to receive attention. If two fingers, held side by side, are passed through the orifice, it will be found, if normal, to admit them readily.

The left ventricle is to be opened by two incisions, one carried transversely across the ventricle, just below and parallel to the auriculo-ventricular groove, and the other extending from the right end of the preceding incision to the lower part of the ventricle on the left side of the apex. The ventricle having been cleansed, the great thickness of its wall is to be noted, and the dissector is to observe (1) that its cavity extends quite to the apex of the heart, and (2) that the interventricular septum recedes from it, so as to be concave on this aspect. The portion of the cavity adjacent to the aortic orifice is to receive attention, this part, which is known as the aortic vestibule of Sibson, having fibrous walls. The columnæ carneæ and their varieties are to be studied as on the right side, their very intricate arrangement being noted, and special attention is to be directed to the musculi papillares, which are anterior and posterior. The two large cusps of the mitral valve, with two small cusps placed between their basal parts, are to be carefully studied, and the relation of the anterior or aortic cusp to the aortic orifice is to be noted. The chordæ tendineæ, and their relations to the segments of the valve, should be closely examined, and the function of the valve is to receive careful consideration. The auriculo-ventricular and aortic orifices are to be studied, but the aortic valve is to be left over for future consideration. Before leaving the study of the interior of the heart, the relations of its auriculo-ventricular and arterial valvular orifices to the thoracic wall should be thoroughly mastered.

Deep Cardiac Plexus.—To expose this plexus the ascending aorta should be divided near its upper end, and the superior vena cava is to be divided a little below the point where it receives the right azygos vein. The arch of the aorta is then to be displaced towards the left side, and kept out of the way by hooks. If necessary, the ligamentum ductûs arteriosi should be divided, but the superficial cardiac plexus is to be left intact. This dissection will expose the thoracic portion of the trachea, in front of which the deep cardiac plexus is situated, just above the bifurcation into the two bronchi. By very careful dissection the nerves forming this plexus are to be shown passing downwards and inwards on the sides of the trachea to its anterior aspect, where they end in the plexus. The deep cardiac plexus is arranged in two halves, right and left, which are in free communication with each other. The contributory nerves to the right half of the plexus are

(1) the upper, middle, and lower cervical cardiac branches of the right sympathetic; (2) the upper and lower cervical cardiac branches of the right pneumogastric; (3) one or two branches from the right recurrent laryngeal nerve; and (4) one or two thoracic cardiac branches from the right pneumogastric nerve. The contributory nerves to the left half of the plexus are (1) the middle and lower cervical cardiac branches of the left sympathetic; (2) the upper cervical cardiac branch of the left pneumogastric; and (3) branches from the left recurrent laryngeal nerve. As regards the upper cervical cardiac branch of the left sympathetic, and the lower cervical cardiac branch of the left pneumogastric, they have already been followed over the arch of the aorta into its concavity, where they have been seen to form the superficial cardiac plexus. The connection between the two halves of the deep cardiac plexus is to be made out, as well as that between the right half and the superficial cardiac plexus. The right coronary plexus is to be shown coming from the superficial and right half of the deep cardiac plexus. From the right half of the deep cardiac plexus branches are to be looked for passing to the right anterior pulmonary plexus, and also to the right auricle. The left coronary plexus is to be shown coming from the left half of the deep cardiac plexus, of which it forms the chief prolongation. Branches are also to be looked for passing to the left anterior pulmonary plexus, and to the left auricle.

The heart is now to be removed by dividing the trunk of the pulmonary artery and the pulmonary veins. The aorta and pulmonary artery are, in succession, to be attached to a water-tap, and by turning the stop-cock the flow of water will demonstrate the action of the arterial valves. The three bulgings on the exterior of each vessel close to the corresponding ventricle, and produced by the sinuses of Valsalva in the interior, will be at the same time shown. The auricular portion of the heart should now be separated from the ventricular portion. There is no continuity between the auricular and ventricular muscular fibres, these being only connected through the medium of the fibrous rings round the auriculo-ventricular orifices. A heart usually requires to be boiled in the first place, in order to dissolve the fibrous tissue, but the separation of the auricular from the ventricular portion is possible by careful dissection. After its completion an instructive view will be obtained of the orifices at the base of the ventricular portion. The auriculo-ventricular orifices will be seen to lie side by side, the aortic orifice being in front of and between them, and the pulmonary orifice being in front of the aortic. In the angle between the auriculo-ventricular and aortic orifices a collection of dense fibrous tissue, of the consistence of cartilage, will be found, and processes are to be shown passing from it to the fibrous rings which surround the auriculo-ventricular and aortic orifices.

The pulmonary artery is next to be laid open by an incision passing between two of the three segments of which the pulmonary valve is composed. The segments of the valve and the sinuses of Valsalva are to be examined, but these admit of much better observation in the case of the aortic valve. The aorta is also to be laid open, observing the same precaution as in opening the pulmonary artery, and the segments of the aortic valve are to receive most careful attention. The two lunulæ and corpus Arantii of each segment are to be noted, the direction of the free margins of the segments is to be observed, and the sinuses of Valsalva are to be looked to. The orifices of the right and left coronary arteries are to be examined, that of the right being connected with the right antero-lateral sinus of Valsalva, and that of the left with the left antero-lateral sinus of Valsalva. Lastly, the function of the aortic and of the pulmonary valves is to be carefully studied.

For the purpose of examining the arrangement of the muscular fasciculi of the auricles and ventricles a sheep's heart may be obtained and boiled for a short time in order to dissolve the fibrous tissue.

Posterior Mediastinum.—The thoracic part of the trachea is now to be dissected, and its bifurcation into two bronchi, right and left, is to be shown, as well as some bronchial glands which lie within the angle of bifurcation. The greater size of the right bronchus and the greater length of the left

bronchus are to be observed, and it is to be specially noted that the right bronchus is more in line with the trachea than the left. The trachea is then to be carefully divided a little above its bifurcation, and the lower part of it, with the two bronchi and two lungs, is to be removed. The right bronchus is to be dissected, and its eparterial and hyparterial divisions are to be shown. The ramifications of the bronchial tubes within the lungs are then to be followed out.

The difference between the main bronchus and its pulmonary ramifications, as regards the extent of the cartilaginous rings in their walls, should attract attention. The bronchial tubes are to be laid freely open, and their mucous lining is to be inspected. The lung is also to be incised at different parts, and the cut surfaces examined. A portion of healthy lung should be put into a dish of water, and the result should be noted.

The thoracic part of the œsophagus is next to be displayed. The dissector is to note that it lies at first on the right side of the descending aorta, then in front of it, and finally slightly to its left side. The right and left pneumogastric nerves will be found in very close contact with the gullet, the right nerve gradually inclining from the right side of the tube to its posterior aspect, and the left nerve gradually inclining from the left side of the tube to its anterior aspect. The plexus gulæ, formed by branches of these two nerves, should be displayed, and the œsophageal branches of the descending aorta are to be borne in mind.

The œsophagus is to be displaced, and the thoracic duct is to be dissected. The dissectors should remember that this duct is sometimes double in the thorax. It will be found lying close to the right side of the descending aorta, between it and the right azygos vein. It is to be carefully followed up beneath the arch of the aorta and along the left side of the œsophagus, on its way to the root of the neck on the left side. The dissectors of the thorax should now associate themselves with the dissectors of the head and neck, in order to follow the thoracic duct to its termination in the angle of junction between the left internal jugular and left subclavian veins.

The descending aorta falls to be dissected next, along with its branches. The aortic intercostal arteries are to be shown on either side, and they are to be followed into the back parts of the intercostal spaces. At this stage the dissector should display the delicate posterior intercostal aponeurosis between which and the parietal pleura each intercostal artery passes. The corresponding intercostal vein and nerve are to be shown in position, and near the angle of the rib the aortic intercostal artery will be found to give off its collateral intercostal branch, having previously, on its entrance into the space, given off its dorsal branch. In dissecting the descending aorta the bronchial arteries which nourish the lungs are to be looked for behind the corresponding bronchus. There is usually one right bronchial artery, which arises either from the descending aorta or from the first right aortic intercostal artery, and there are two left bronchial arteries, which spring from the parent trunk.

The azygos veins are next to receive attention. The right azygos vein will be found under cover of the œsophagus, where it has the thoracic duct on its left side, and it is to be followed up to its termination in the superior vena cava, a tag of which vessel has been specially preserved. The following tributaries are to be shown entering the right azygos vein: (1) the lower seven, or it may be eight, right intercostal veins; (2) the lower and upper transverse azgyos veins; and (3) the right superior intercostal vein, which takes up the second and third, and it may be the fourth, intercostal veins of the right side. The first right intercostal vein opens into the corresponding innominate vein, or sometimes into the vertebral vein. The lower and upper left azygos veins are then to be dissected, along with the lower and upper transverse azygos veins; and the left superior intercostal vein, if not previously dissected, is to be followed over the back part of the arch of the aorta, and shown entering the left innominate vein. The first left intercostal vein is disposed similarly to its fellow of the right side.

The superior intercostal artery on either side is to be dissected, and its

distribution to the first and seond intercostal spaces shown. The vessel will be found descending in front of the neck of the first rib. A branch from the first aortic intercostal artery—that, namely, to the third space—should be looked for ascending over the neck of the third rib to join the second intercostal artery, which it sometimes replaces.

The thoracic portion of the gangliated cord of the sympathetic should now be dissected. It will be found lying over the heads of the ribs under cover of the parietal pleura, and gradually inclining inferiorly on to the side of the vertebral column. Two rami communicantes are to be shown passing between each ganglion and the adjacent intercostal nerve, and it is to be noted that these rami are very short. The vascular branches of distribution of the upper ganglia, as well as the branches to the posterior pulmonary plexus of nerves, are not easy of dissection, but the splanchnic nerves admit of this readily, the great and small splanchnic nerves being constant, but the least being frequently absent.

The upper surface of the diaphragm is next to be dissected, and attention should be directed to (1) its thoracic relations, (2) the central tendon, (3) the foramen quadratum, (4) the aortic and œsophageal openings, and (5) the relation of the sympathetic cords and splanchnic nerves to it. The diaphragm may now be laid open, in association with the dissectors of the abdomen, and the thoracic duct is then to be followed down to its commencement in the receptaculum chyli. Thereafter the subcostal muscles should be dissected. They will be found over the back parts of the ribs in the vicinity of the angles.

Articulations.—1. **Vertebral Column.**—The part available for the dissection of the ligaments is the portion below the first thoracic vertebra, and probably as low as the tenth or eleventh thoracic vertebra. The ligaments to be dissected are (1) the anterior common ligament, which is easily displayed; (2) the posterior common ligament, to show which the neural arches of the vertebræ must be removed by sawing through the pedicles; (3) the intervertebral discs, which are to be dissected by means of transverse and vertical sections; (4) the ligamenta subflava, which connect the laminæ, and are readily seen after removal of the neural arches; (5) the capsular ligaments, which connect the articular processes; (6) the supraspinous and interspinous ligaments; and (7) the intertransverse ligaments.

The movements of the vertebral column are to be carefully studied.

2. **Ribs—Costo-central Joints.**—The ligaments to be dissected are (1) the anterior costo-central or stellate, easily recognised; and (2) the interarticular, which is only seen on opening the joint, and which is absent in the first, sometimes the tenth, the eleventh, and twelfth joints. The two synovial cavities are to be noted, except in the case of the joints just enumerated as having no interarticular ligament.

Costo-transverse Joints.—The ligaments to be dissected are the posterior, middle, and superior costo-transverse. Within the posterior costo-transverse ligament the synovial membrane of the joint is to be shown. The middle costo-transverse or interosseous ligament can only be studied properly by sawing horizontally through the neck of the rib and the adjacent transverse process. The superior costo-transverse ligaments are to be displayed as two distinct bands—anterior or external, which is large; and posterior or internal, which is small. The continuity of the outer border of the anterior ligament with the posterior intercostal aponeurosis is to be shown.

Costo-chondral Joints.—Each rib is connected to its cartilage by the continuity which takes place between the periosteum of the rib and the perichondrium of the cartilage.

Sterno-chondral Joints.—The ligaments to be dissected are anterior, posterior, superior, and inferior. In the case of the second joint, and it may be in some of the succeeding joints, there is an interarticular ligament, which divides the joint into two distinct synovial compartments. The direct connection of the first costal cartilage with the manubrium sterni is to receive attention.

Interchondral Joints.—These are met with from about the fifth to the

ninth or tenth costal cartilages. They are provided with capsular ligaments and synovial membranes.

3. **Sternum.**—The manubrium and body are connected by ligamentous fibres, disposed longitudinally in front and behind, and by a plate of fibro-cartilage which is interposed between the articular surfaces. It is to be noted that the entire sternum is strengthened by its dense periosteum, by the radiating fibres of the chondro-sternal ligaments, and by the tendinous fibres of origin of the pectoralis major muscles.

The movements of the ribs are to be studied with the greatest care, and the muscles concerned in these movements are to be specially noted.

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